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CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT – DANEMARK

JOURNAL DU CONSEIL

VOL. XV · NO. 1

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RÉDIGÉ PAR
J. R. LUMBY

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
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JUILLET 1947

Notice.

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IMPRIMERIE A/S L. IHRICH

Obituary.

During the past 6 years, the deaths have occurred of several delegates, experts, and others associated with the Council. Their names were spoken by the President at the meetings of the Council in October 1945 and in August 1946, and their memory honoured by a minute's silence. In the normal course, it might also have been our privilege to publish memorials of those who have lost their lives, but the length to which the list has grown during the years in which the Journal did not appear precludes — it is realized with the greatest regret — the possibility of doing so now, except in a few cases. These memorials will appear in later issues of the Journal. In the list given below, besides the names mentioned by the President, are included a few of whom news has been received since the Council met, together with a note of their association with the Council.

Belgium.

Gustave Gilson (1859—1944): Delegate, 1901, 1904—24, and since 1926; Expert, 1925; Guest, 1903; Vice-Chairman, Combined North Sea Committee, 1928—31; Chairman, Combined North Sea and Eastern Channel Committee, since 1931.

Denmark.

F. V. Mortensen (1865—1942): Expert, 1910—13, 1921—22, 1924—26, 1928, 1930.

W. Nellemosé (1890—1944): Administrative Secretary, since 1932.

J. P. Jacobsen (1877—1946): Hydrographer to the Bureau, since 1928.

Finland.

Rolf J. Witting (1879—1944): Expert, 1909—13; Delegate, 1920—35.

France.

Théodore Tissier (1866—1944): Delegate, 1920, and since 1922; Vice-President, since 1921.

Louis Roule (1861—1942): Expert, 1921, 1925, 1929, 1933.

Germany.

E. Ehrenbaum (1861—1942): Expert, 1905, 1907, 1909—13, 1927—33.

Erich Fischer (1875—1943): Expert, 1912, and since 1928.

Carl Heinrici (1876—1944): Delegate, since 1926; Vice-President, since 1927.

Ernst Hentschel (1876—1945): Expert, 1934—36, and since 1938.

Bruno Schulz (1888—1944): Expert, since 1929.

S. Strodtmann (1868—1946): Expert, 1928, 1930, 1932, 1934, and 1939.

H. Thorade (1881—1945): Guest, 1931, 1932, 1934.

Hermann Wattenberg (1901—1944): Expert, 1928, 1934—36, 1939; Guest, 1931.

Great Britain.

E. J. Allen (1866—1942): Expert, 1909 and 1920; Guest, 1934.

Frederick M. Davis (1889—1940): Expert, 1925, and since 1929.

J. Stanley Gardiner (1872—1946): Expert, 1920.

Stanley W. Kemp (1882—1945): Guest, 1938; Expert, 1939.

Douglas S. Raitt (1903—1944): Expert, 1936, 1939.

Netherlands.

H. C. Redeke (1874—1945): Expert, 1904—12; Delegate, 1913—25; Chairman, Plaice Committee, 1912, 1920—22; Limnological Committee, 1920.

Norway.

Oscar Sund (1883—1943): Expert, 1920, 1926—36; Delegate, since 1937; Vice-Chairman, North-Eastern Area Committee, 1927—38; Chairman, since 1938.

Poland.

Michal Siedlecki (1873—1940): Guest, 1924; Delegate, 1925—39; Chairman, Salmon and Trout Committee, since 1931.

Spain.

Odón de Buen (1863—1945): Delegate, since 1924.

Sweden.

Otto Pettersson (1848—1941): Delegate, 1899—1933; Vice-President, 1902—15, 1920—32; President, 1915—20, Président d'Honneur, since 1932; Chairman, Editorial Committee, 1908—37; Savings Gear Committee, 1929.

The Flødevig Sea Fish Hatchery, at Arendal, Norway.

By

Alf Dannevig.

THE Hatchery at Flødevigen is a fairly old institution, dating from 1882. In the earlier part of its existence it was very much in the public eye, and its usefulness was widely discussed both at home and abroad. Although in later years not much has been published about it, the work at the station has been kept going. New apparatus has been constructed and the accomodation has been enlarged. The purpose of the present paper is to give a short sketch of the history of the station and the broad lines of the work. Descriptions of apparatus and methods employed are to be found in the papers mentioned.

The principal work at the station was originally to hatch cod eggs and liberate the fry in the small fjords of southern Norway, for which apparatus was constructed and methods devised.

As to the practical results of the work, opinions differed, however. The fishermen and the population along the fjords where cod fry was liberated were generally in favour of the work. The fishermen along the open coast were mostly indifferent, or of the opinion that the money was spent in vain. They had seen no practical results of the output of the fry.

Some of the scientists were in favour of the work. By others it was claimed that the output of pelagic larvae was of no consequence. The larvae were apt to be taken out to sea by the surface current.

In the years 1903 to 1907 fairly large experiments were carried out in order to get numerical assessment of the effect. Certain fjords were selected and fished in some years with a small seine. The number of cod (and other fish) of the 0-group was recorded. Alternately cod fry were liberated in the fjords.

The numerical values thus obtained supported the station's work. The question then arose as to what degree these positive results were

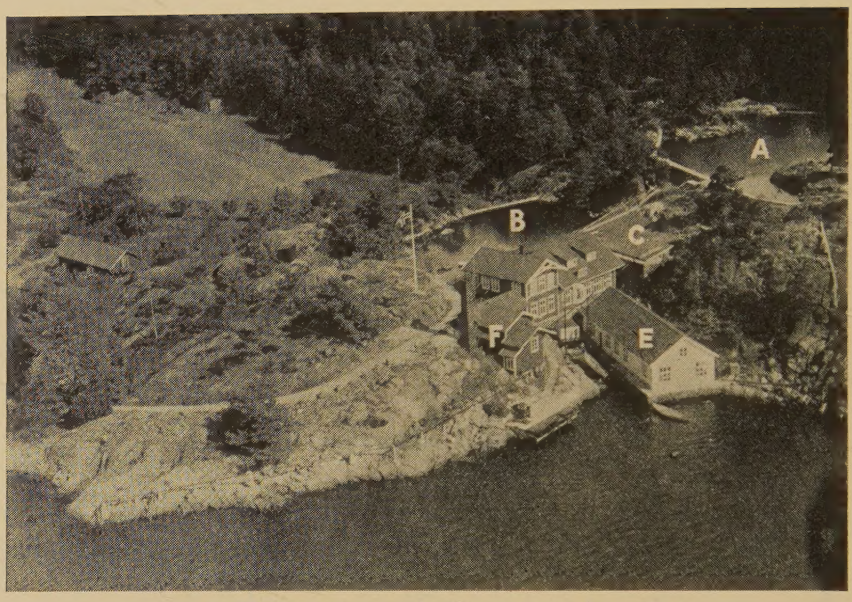

Fig. 1. The Hatchery and salt-water ponds in 1936.

A. Pond for oyster culture.
B. Pond for rearing experiments, and salt-water reservoir.
C. Spawning pond (under roof), approximately 19×6×3 m.
D. Hatching room for cod and lobster, 19×10 m.
E. House for lobster rearing, 21·60×7·90 m.
F. Pump house, removed in 1939.

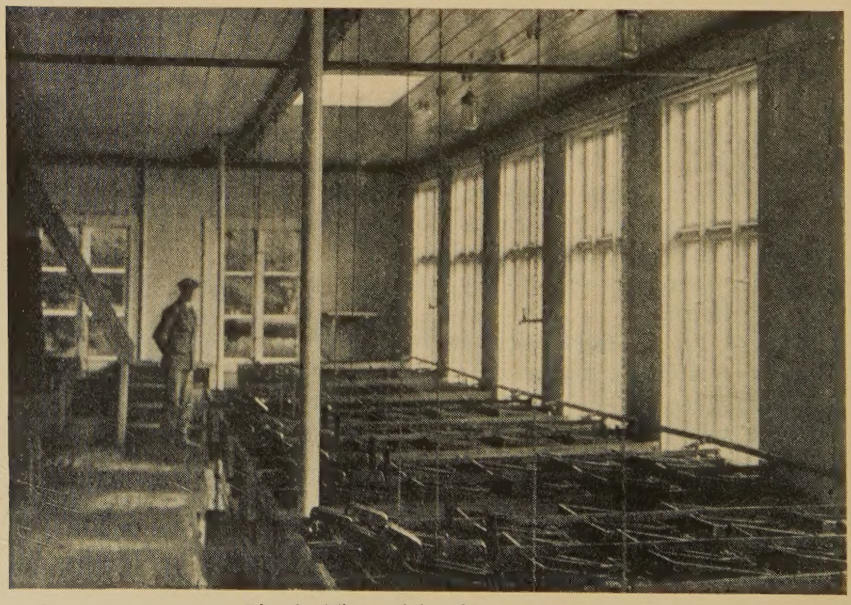

Fig. 2. The cod hatching apparatus

to be ascribed to the liberation of fry, or to exceptionally favourable breeding conditions for the fish eggs in nature, or to the effect of the current. In order to clear up the problem the Norwegian Parliament in 1909 elected a special committee to report on the question.

The committee was composed of the following members: Inspector of Fisheries A. Landmark (Chairman), Professor A. Appelløf, Professor H. H. Gran, Director of the Biological Station in Trondheim O. Nordgaard, and Shipowner Thv. Hansen (representing the districts interested).

After discussing the problem the committee was unable to decide whether or no the liberation of pelagic cod fry was practically useful,

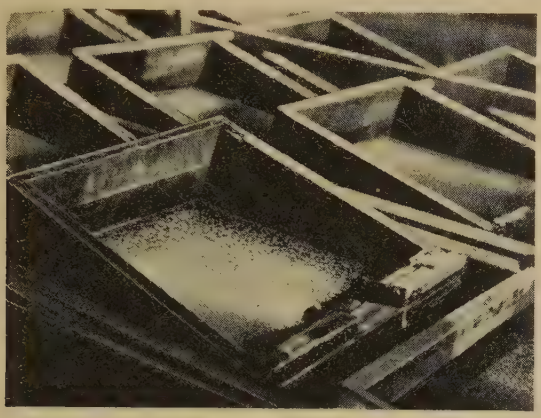

Fig. 3. One box 12½×11½×10½ inches containing about 0·4 million cod larvae.

but recommended that the practical work should be continued, along with scientific investigations of the problem. Professor Appelløf was of the opinion that the hatchery was of no consequence.

As the present writer in 1911 succeeded the former director and founder of the hatchery, Capt. G. M. Dannevig, it was natural to follow the scheme laid down by the committee.

The hatchery operations have since been kept going as experiments on a large scale. Millions of cod fry have been hatched and the different problems brought to light have been investigated as far as the means have been available.

The hydrography of the fjords has been examined, especially during spring. The amount of fish eggs and larvae has been recorded in several waters and the success of the natural breeding has been studied. The occurrence of the 6-month-old codlings has been controlled by experimental fishing in several fjords from 1917 to 1939. The fate of the older year-classes has been followed by experimental fishing in three localities from 1922 onwards. The migrations of the coastal cod have been studied by marking experiments, and racial problems have been touched upon by vertebrae counts.

In this way we have tried to get a solid basis from which we may start to discuss the problem of the usefulness of the liberation of pelagic cod fry. The results so far have demonstrated that the hydrography of the fjords and the biology of the cod here suit the scheme. But there is one great problem which we were unable to attack until we got our new laboratories in 1939; that is the requirements of the pelagic larvae as regards food, temperature, salinity, oxygen, and light. This study involves large-scale experiments in the laboratory and intense study in the field.

By this means we hope to get information as to where and when the larvae are to be liberated.

Besides the hatching of cod eggs, we have also worked with lobsters and oysters. In 1893 Captain D a n n e v i g succeeded in hatching the lobsters eggs stripped from the animal. The lobster problem was, however, not carried further here until 1916 when we began experiments on the rearing of lobster larvae. In 1923 we succeeded in finding a

Fig. 4. Boxes for transporting pelagic larvae.

practical method and in 1932 a new building was put up for lobster rearing. The work has been treated as a large-scale experiment. In the last year, 1939, 78,600 lobsterlings in the bottom stage were liberated and 106,000 in earlier stages.

Till now our chief object in lobster rearing work has been the endeavour to get the greatest output for the least expense. As to recording the result of the liberations not much has been done up to the present, but the biology of the lobster in nature has been studied, the migrations, growth, and the influence of temperature on the fishing operations.

In 1933 a salt-water pond was built for experiments on oyster culture. Some years previously we had started to deal with the oyster problem in the southern part of Norway. The growth-rate of the oyster was very high, but often high mortality occurred. The results

Fig. 5. Apparatus for lobster rearing. On each side are 10 boxes 128×145 cm. with a depth of 96 cm. The water pipe in the middle.

of our experiments point to the fact that the oyster spat from the local ponds give better results by far than spat from the western part of Norway. The high mortality among spat from western Norway may be the result of transport, but there are also indications that the cause may be physiological. It may be that the oysters from western Norway cannot stand the brackish water which often occurs on the southern coast.

It will be seen that the scheme of work at Flødevigen has been greatly extended in later years, to deal with the problems of the coastal fisheries in southern Norway.

The Hatchery was started by subsidies from private persons and public funds. In 1916 the Hatchery was taken over by the Government. In 1938 means were granted for a new laboratory. This was

Fig. 6. The Laboratory.

built in 1938/1939 and from that time we have been able to carry out experiments on the behaviour especially of larvae of fishes and oysters.

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Practical Proposals for a Continuous Programme of Thick-Layer Current Measuring in all Weathers with Remarks on Relevant Wind Observations and other Related Matters.

By

J. N. Carruthers,
Hydrographic Department, Admiralty, London.

IT is of course perfectly well known to all readers of this journal that the wise aim of the Council is to work for the "Rational Exploitation of the Sea". Now that the time has come to resume the researches designed to lead to the achievement of that aim, it seems good to urge that all investigations should be planned in keeping with the principle of rational application of effort.

Really useful knowledge concerning the water movements in many areas of sea wherein important food fish spend the early stages of their lives is much to be desired, and should be copious in amount. On this point there will be no lack of agreement, as plans of work being formulated at present amply attest. Since facilities and resources are necessarily limited, it behoves us to plan the necessary investigations in such a way that effort will not be wasted. It is entirely possible to adopt a severely practical attitude to the end of collecting a large mass of useful information with the minimum of trouble, and with negligible cost in respect of wear and tear of apparatus. As regards available current-measuring instruments, is is not proposed (because it is not necessary) to load this article with any list naming the numerous types, but it may be noted in passing that since the present writer last contributed to the pages of the Council's publications, a few new instruments have made their appearance. Most noteworthy of these perhaps is the Roberts Current-Meter (1).

This instrument enables an investigator ashore to receive information as to current strength and direction by means of automatic radio signals from the instrument left working suspended from a buoy. German oceanographers developed new types of instrument during the

War, and it is hoped to publish an account of them in due course. Passing reference may be made to a "dye-streak" method worked out by K a l l e. "Ausarbeitung einer bereits erprobten neuartigen Oberflächen-Strommessung mittels Fluorescein-Natrium". It has been learnt (2) that Spanish oceanographers also have constructed a new instrument, but no account of it has yet been seen by the writer.

The all-important question which an investigator of sea currents should first ask himself is just what information he would most like to possess — what it would most profit him to know in his attempts to elucidate the many problems which confront him. This might seem so obvious as to be hardly worth the saying, but there would seem often to have been far too much attention paid to the beauties of various instruments, and to claims as to what they could do, when the main consideration should be, — "What will actual working conditions in the sea let the various instruments do towards the production of data which can be held to possess real promise of usefulness?" This is the crux of the matter indeed, and the main theme of this present article is to urge yet once again that only scant value can possibly attach to researches which last but for short periods and relate only to calm weather — when it is current-measuring that is in question.

The use of drift-bottles presents little trouble in respect of material, but much labour in interpretation. Bottom-trailing bottles have not been a great success used in their best-known form, for in the southern North Sea at any rate, they "take sanctuary" between the sand ridges so impressively described by J. V a n V e e n. Surface bottles of the usual modern type, even though properly ballasted, leave much to be desired. It has been proved beyond any doubt [(3) and (4) — Figure 9] that deep-riding bottle systems perform travels which are effectively ruled by wind conditions. A change in wind conditions brought about an impressive change in travel direction, and since such a change in travel direction would be more quickly imposed upon ordinary surface bottles, it follows that large-scale experiments with ordinary surface floaters and deep-riding bottles, made contemporaneously, would sometimes yield very different results. That being so, then since the fishery researcher is not interested particularly in the movements of the topmost thin layer of water to the exclusion of layers beneath, it is necessary to guard against inferring too much from the travels performed by simple surface drift-bottles.

As to the practice of computing currents *via* the method associated with the name of B j e r k n e s, this does not serve for the shallow waters of the southern North Sea. It has, of course, been much used in respect of the waters flowing into the Norwegian Sea and northern North Sea from the Atlantic through the Faroe—Shetland Channel, the classic area of oceanography. In recent years A. E. P a r r has written adverse criticisms concerning the showings of the method in respect of the movements of water off our north-western seaboard.

It would seem that the time is ripe for the carrying-out of a critical

experiment; that all possible effort should be devoted (and it would be a very worth-while research indeed!) to measuring the rate of surface water flow through the Faroe—Shetland Channel by dint of observing the drift of floats at a time when ample provision was being made also for the collection of traditional data designed to permit the carrying out of hydrodynamical calculations proper to the same period. In this "float-following" programme, full use of various modern position-fixing devices would be made, of course.

Let us return to the consideration of a realistic programme of current-observing, and let us relate it to the southern portion of the North Sea where there are so many problems of great interest and importance which concern important food fish. Of late, various relevant suggestions have been made in memoranda circulated by the Council. Much in these has had to do with projects for following floats, and the present writer would remark that, when considering the declared ends in view, a measure of attention could profitably be given to excellent past researches having the same object which are associated with the name of the late F. M. D a v i s.

Supposing that it were possible to carry out a programme of float-following in the Southern Bight of the North Sea, just what would we learn? It is not obvious that it would be practicable to follow the movements of a number of floats set adrift at intervals of time, unless resources of considerable magnitude were possessed. Because of this consideration, the present writer designed his Crossbow Float [(5) and (6)] and though tests were not far advanced by the time war broke out, sight has not been lost of pursuing the matter further.

Data obtained from established journeys accomplished by deep-riding floats, would be just ideal in the view of a worker whose job it is to prepare charts of water movements (of tidal streams) for use in the compilation of atlases for the benefit of shipping, though such a man would wish to know also how floats set out earlier and later would have travelled.

That a great deal of very useful information in this important line of research can come from the use of floats (particularly when shore-watching is possible) is amply attested by the accounts published by S c h u l z relating to work done by the Germans off the Flanders coast during the 1914—18 War.

What, we must ask ourselves, would people with other interests learn; in particular, what would the fisheries scientist learn that he could not learn in other ways as part of a programme having perhaps a wider scope?

Supposing that the float to be followed were constructed to ride 20 metres deep, then at the start, its movements might be taken to reveal not only how the cubic chain of water plumbed by it moved initially onwards, but also how the content of that cubic chain of water (in respect of fish eggs, larvae, etc.) moved away from the starting point. Since, however, when the float had travelled some material distance, it

could no longer be claimed that the cubic chain of water then around it would contain the same organisms as initially, we must, unless a number of floats could be followed, seriously consider whether we should be applying effort and resources in the most profitable manner by pursuing this line of research.

When the proposed schemes of research envisaging the use of floats and nets are weighed up in all their aspects, it seems to the present writer that effort might well be applied more profitably along different lines.

Assuming that means had been decided upon how best to learn what content of organisms of interest was present in the water at as many places and at as many depths as possible — what of the related current-observing?

It is held that the best plan would be to aim at the production and maintenance of a wide synoptic picture. Lightships would be used to the greatest extent possible once they were back on station, and it is no more than a sober statement of fact to claim that continuous (all day for all weathers) records of water movements could come *from all lightships* using apparatus of a type at present in existence.

Throughout winter 1938/1939 non-stop observations on current were carried out from ten lightships in the North Sea (7), and such observations have already been set in train again from Dutch lightships (so Dr. V a n V e e n has informed the writer). The apparatus used was the Vertical Log Current-Meter of which accounts have been given (with records of work done) in the publications of the Council. For a description of the instrument, the reader may be referred to *Fisheries Notice* No. 26 issued gratis by the Ministry of Agriculture and Fisheries since August 1939. It is the business of this present article to show how the instrument could be modified in a simple enough manner (using only parts which have stood up to the tests of stern usage) to make its employment even more useful, still simpler, and in the long run, still cheaper.

The Scheme.

Years ago, when charged with the duty of scheming researches on currents which could be expected to be of maximum benefit to fishery research requirements, the writer first listed the considerations which could not be evaded.

First and foremost it was necessary never to lose sight of the fact that it is in winter that so many events of interest are in train. This meant that one had to produce an instrument which would work in all weathers, since a period of wild weather might very well have critical influence upon the fortunes of a fish brood, for instance. Who can say that the fortunes of a herring spawning may not be decided to some extent by the destruction of ova by silt churned up during a gale?

The problems called for the construction along rather novel lines of a new instrument of special design. All existing current-meters of the

self-contained type, i. e., ones whose rotor is rigidly connected with the registering mechanisms, and which work at the end of a line let down from a ship, were open to serious objection even if they could have proved robust enough to stand up to gruelling working conditions for months on end. Such instruments must inevitably put on many registrations due to being lifted, dropped, and towed through the water by reason of movements of the ship, particularly in bad weather. Not only must they inevitably do so, but the spurious currents so recorded are inevitably mechanically allotted to a wide spread of direction. It was not seen that an instrument of pressure-plate type would offer satisfactory escape from this serious trouble, and one had to have always in view the ultimate hope of working the instrument from a buoy to economize ship's time when observations other than from lightships came to be undertaken. Since a buoy is but a ship in miniature, the problem of avoiding the registration of spurious current would be even greater using most existing instruments.

One had to think along new lines, and the simple and very strong Vertical Log was the result. This instrument cuts down the registration of adventitious current to a minimum, as is explained in published accounts of it.

It was decided to give it a long trial under all possible conditions, and then to proceed further along lines which would result in the production of a version of it which could work completely automatically.

That severe trials have been given in ample measure is witnessed by published all-weather records coming from English, French, Dutch, and Danish lightvessels.

The proposed modification of the Vertical Log, which it is suggested should be made and taken into use aboard as many lightships as possible, will now be described. When this modified version has been made and used extensively, it is proposed to work towards an ultimate stage, to make possible the use of it from a "buoy" which could perhaps be a sort of large-size Carley Float or consist of two baulks of timber dogged together with a space between and carrying a small "hutch" built on to them.

Prior to the attainment of this ultimate stage, however, it should always be borne in mind that there would be no present difficulty at all in using several sets of cups tandem-fashion so as to get information on the movements of a very thick layer of water indeed. This could not but have attractions for those whose interest lies in the dispersal of floating eggs and other planktonts.

It is suggested that the spindle box of the Vertical Log be hung something more than head-high from a yard abaft the waist of the lightship. The box would be covered by a watertight lid, and the rotating spindle would be made to turn a small horizontal rod carrying an eye which would project through the shipward side of the spindle box. This eye would be able to take pull, by suitable provision of a small thrust-block device inside the box. The result would be that one

could lead a log-line inboard which would turn in keeping with the rotation of the submerged cup system.

The rest of the proposed arrangement can best be described (for reasons of simplicity) in terms of rather crude materials in order to convey the ideas.

Over the opposite rail of the lightship — preferably, but not necessarily in line with the yard carrying the cup system — would be a sort of a "rudder" held in a strong bracket clamped to the rail. This above keel depth, would be merely a stout round iron rod able to turn in an obvious enough manner in two holes some feet apart in the vertical to ensure proper holding.

Below keel depth, either there would be a rudder blade attached to the rod, or this latter would have a bend at something greater than a right angle. From the heel of the rudder or from the end of the rod, would be streamed an object like a Jacobsen Meter cylinder (in effect a small bottomless ashbin hung on a crow's foot) or a pyramid as favoured by J. Van Veen.

On the top of the vertical rudder rod would be mounted (tight on, to turn with it) a small gypsy-wheel parallel to the deck.

This wheel would of course be a foot or so outboard, and would carry a marker boss to indicate alignment with the submerged "rudder", which latter would be able to turn through a full circle.

On deck, near the customary binnacle position of an old-time lightship, there would be a small round turntable secured atop a corresponding gypsy-wheel itself mounted upon a sort of spinning bollard of suitable height. The result would be that we should have a rotating table in the midship line which could easily be made to keep orientation with the "rudder". This could be simply achieved by connecting up the two gypsy-wheels either by a cheap brass (non-magnetic) chain, or by a suitable rubber cord and if desired, all could be above head height to avoid deck obstruction. In practice (in the future), a sort of rack bar would perhaps be preferred as constituting a more suitable and workmanlike link. On to this rotating round table would be secured (to turn with it) the radially-divided, ball-receiving compass box of a Drift Indicator. This, a sort of large-size version of the corresponding Ekman Meter ball-receiving box, can be seen figured on page 11 of *Fisheries Notice* No. 17, issued gratis by the Ministry of Agriculture and Fisheries since July, 1932.

Suitably mounted above this ball-receiving box (which would contain the usual pivoted compass of vulcanite tube type as figured on page 12 of the pamphlet just cited) would be a hopper of phosphor-bronze balls with a fitted dropping mechanism analogous to that of the Drift Indicator. It is to be noted that all these inboard parts could be of much cheaper construction than they have to be when working under water as components of the Drift Indicator.

The ball-dropping sphere would be turned by the log line earlier referred to as coming inboard from the Vertical Log Spindle Box

There would have to be provision for a small thrust-block device mounted on a suitable bracket near the ball-dropping sphere to take pull off the latter, and there would, no doubt, be need for some gearing.

It would be childishly simple to arrange for the sphere to drop 3 balls, or 6 balls, or any desired number per rotation.

This proposed marriage of the Vertical Log and the Drift Indicator would certainly mean the provision of an automatic current-meter which could be installed on all lightvessels to work continuously in all weathers, and would produce data relevant to ship draught.

There would be no need to empty the balls more than once a week, say, and there would be no difficulty in weighing them in terms of miles by means of a simple balance if counting were frowned upon. Keeping the records would be child's play — just 16 entries to be made on a simple form which carries a diagram of the receiving box in horizontal section (see page 25 of the last-cited pamphlet), and this perhaps only once a week.

It is good to remember that the amount of co-operation to be looked for when carrying out such a useful and continuous programme of work as that envisaged would depend upon the production of information of use to workers having various interests.

By its very nature, the apparatus just crudely sketched in words would measure the water movements at a depth of interest to shipping. and there is no reason whatsoever why the same apparatus should not be used to observe tidal streams as such in an appropriate manner. Clearly, one could arrange to run the apparatus just for a quarter of an hour, say, each side of Dover high-water time, and similarly for other hours referred to that standard reference. To do this would of course cut into the continuous recording, but it would usually be necessary to do so only on occasion; otherwise a second instrument could be brought into use. It would even be no hard matter presumably to make the Vertical Log work two inboard parts, one to be employed for unbroken observations and the other for special tidal stream recording and the like. If we did provide a special inboard part to be used for tidal stream observations due to be continued for many days, it would easily be possible to have 13 cheap numbered ball-receiving trays, each to be labelled for the appropriate tidal hour from Dover H. W. — 6 to Dover H. W. + 6.

In the case of the continuous observations designed to yield simple data on overall water movement over, say, weekly periods, it would be possible to use numbered calico bags and a pouring-out disk as was Drift Indicator practice; this would achieve that the records were broken into for only five minutes or so at each emptying time. The bags of balls would be put on one side for counting at leisure, if counting were preferred to weighing in miles.

It would be a good idea to fit a simple master-counter to record the number of turns made by the log line as a check against the total

number of balls dropped. Such a cheap and simple fitment would serve an additional and potentially very valuable function, for it would be possible to time a suitable number of rotations and so learn (on referring to a simple table) what was the speed of water movement on any occasion. Knowing this and the stream direction (without even glancing over the side) it would be possible to supply shipping beset by fog with radioed information as to how they were being set. As some guide to revolution speeds and related matters, it may be remarked that the Vertical Log, as hitherto used, put on about 300 revolutions for each mile of passing water (miles of 6,080 feet being in question). In a 3-knot stream the cups turned 15 times per minute.

The Drift Indicator used to drop 24 balls per mile of water movement; using a dropping sphere with 3 holes, this means 8 revolutions of the latter per mile run by the water. To maintain the like frequency of registration, it would be necessary to fit gearing to achieve that, for each 40 or so turns of the Vertical Log cup system, the ball-dropping sphere would rotate once at the bottom of the ball hopper. There is easy scope in the choice of gearing, for the number of "ball-removing-holes" in the dropping sphere can be altered with simplicity.

So much for a sketch description of the composite instrument proposed as it would be in its first stage of construction, and as it could be used from a score and more of lightships to provide a wide synoptic picture of the currents throughout all weathers.

It is to be remarked that the Dutch lightvessel observations, understood to be already in train again, will supply information upon the arrival currents in the area of the plaice nurseries, and it should be emphasized that these currents are under the sway of changing wind conditions to a degree which defies prediction. This only emphasizes the need for *continuous* observations, as a glance at sample Dutch records presented in graphical form will show (e. g., (4) Fig. 7).

Once the instrument above described had been put to use and thoroughly tried out, it would be possible to consider certain improvements and modifications which would make it even more useful for certain specialist purposes, though no better (because no equally simple) form could probably be chosen for the long-period needs of the fishery researcher. It will be convenient to return to this matter later.

Wind observations.

The present writer considers it almost impossible to over-estimate the importance of keeping a suitable record of wind observations for use in connexion with studies upon water movements, and has in fact kept such a record throughout the War. By suitable, is here meant data on overall mileage run of wind towards certain directions as worked out for daily and weekly periods.

Very promising results have been obtained when making a parallel study of wind conditions and various matters of fishery research interest, as told in the pages of a paper already cited (4), and fisheries

research workers in America and other countries have also gone to pains to work out data to suit them from official records of wind strength and direction as traditionally recorded.

Some years ago, the writer proposed the construction of a special totalizing anemometer (9). It would be of very great value indeed to have simple weekly records of mileage run of wind in various directions. To get these, one would not need to possess an instrument of sensitivity great enough to appeal to professional meteorologists. It is on record that a Hamburg firm of precision instrument makers constructed a totalizing anemometer but of a type much more complicated and sensitive than is needed by the oceanographer with interests on a mundane level. Also, the Japanese worker K. Yakame has described (circa 1939) "A new Component Anemometer", but his instrument also is much too good for the simple needs here being considered; for these, strength, simplicity, modest cost, and reliability are of paramount importance.

If one could have a suitable strong and simple totalizing wind-measuring instrument installed at strategic positions round the southern North Sea alone, one would have gone far in a promising direction, for the water movements therein are so powerfully ruled by wind. It is possible to describe a simple instrument which would suit.

A set of cups (3 or 4 as desired), mounted to rotate at standard height on the top of a pole, would be geared to turn a vertical rod which, in turn, would rotate a vertical wheel mounted down below at suitable height. This wheel would lie in the meridian.

Pivoted loosely at its centre would hang a metal bar, and this bar would be carried round by the wheel by the push of one small projecting boss situated, say, half way along a radius. On passing top, the bar would fall freely and deliver a blow towards North.

Away from the "cups pole" would be another pole with a wind-sock at the top. This pole would have a sharp hard steel spike at its foot resting on a steel plate, and would turn with the sock. By gypsy-chain connexion or some other suitable device, a round table pivoted on a stump near the cups pole would turn in sympathy. This small turntable, and what it bore upon it, would be under cover in a small hutch. The round table (or rather a metal disk above it and turning with it) would be cut up into 8 or 16 sectors each of which would be borne upon a weak spring arm secured at the centre.

Borne also on arms from the centre (and designed to turn with the radially-divided turntable) would be high-angle metal separators in vertical section triangular like a very narrow inverted "V". These would cover off the cuts where the sectors adjoined. It would be arranged that pressure on any sector would pull down a cord leading up to a snatch counter. Thus, a blow delivered at the edge of the turntable by a metal bar, say, would necessarily affect one sector only, and would count one for that sector. It can be seen that, by bringing the recording sector table near to the cups pole, (so avoiding

interference) one could arrange to get a record of wind mileage run in different directions over a period. Such a rough instrument as that just sketchily described would probably not be found to possess a very good calibration factor. It would not be very sensitive either, and so could best be called something equivalent to "Strong Wind Totalizer". But the data from it, simple and of small bulk, would be of great value to those whose job it is to study the interdependence of air and water movements. In practice it might not be found best to use snatch counters and sectors borne on spring arms. It would easily be possible to hinge the sector arms in such manner that they were kept horizontal by the upwards pull of lightly weighted cords passing over ratchet wheels connected with such simple, cheap, and reliable counters as are obtainable from the makers of gas meters (and employed in the recording parts of Vertical Logs as hitherto used).

In the case of the anemometer also, a master counter could be rigged to count the rotations of the wheel on the cups pole to provide a check.

With such a wind-measuring device as that described, all we would need to do would be to read a number of counters. If, however, a ball-dropping device were preferred for extra simplicity, this could be designed with great ease, since there is no compass to consider. The rotating cups would serve to cause a delivery of balls down a spout projecting towards North, so as to fall into the compartments of a radially-divided circular box mounted on a turntable kept in gypsy connexion with the sock pole. Using the anemometer in this ball-dropping form, one would presumably prefer to weigh the balls to get miles to save the labour of counting.

Given adequate tolerance on the part of lightvessel authorities to the effect that their vessels could be used rather as observatories, it would be perfectly possible to go one step further and arrange to obtain simple overall wind data of the type sought from the open sea wherever lightships were moored. This would indeed be a boon, for such wind data are used to make as good an inference as is possible regarding water movements in places where it is not possible to observe the sea currents, and are directly applicable to studies on the distribution of herring shoals etc.

A ball-dropping totalizing anemometer would be an easy installation to arrange for aboard an anchored ship.

All necessary would be to provide a radially-divided compass-fitted ball-receiving box mounted on a small turntable which would turn in keeping with a drum secured round the wind-sock post (by means of a stretched rubber belt), and would receive balls from a forwards-pointing spout leading from the funnel into which the ball-dropping sphere dropped the balls it removed from the hopper.

A Future Registering Device for Current-Meters.

The snatch-counter method of registration (believed novel), described above for use with the anemometer, can be referred to for brevity as "Hatchet Registration". It would not be suitable for use in current-meters wherein compasses have to be employed.

It is, however, quite easy to think out a method of registration which could be incorporated into the "on shipboard recording" current-measuring instrument earlier described. No departure from ball-dropping registration would seem to be desirable for purposes of fisheries research, however.

One could let the inboard turntable which turned with the "rudder" carry an annular fringe of thin sheet rubber round its periphery; this sheet of rubber would carry metal type on its underside in such manner that 32 equal sectors were labelled respectively 1 to 32, and the sector numbered unity could also carry a metal letter "C" for "Current", it being intended that this sector should be aligned to be aft when the rudder was dead aft as seen from the indicator spoke at rail level.

Near by, with its periphery approaching to within a couple of inches or so, would be a large, substantial, and stable pivoted compass card also provided with a peripheral annular rubber fringe. This latter would likewise carry metal type underneath serving to label the degrees from 0 to 360, but also would have type to print the cardinal and intervening main points. A simple and robust clockwork would cause a paper strip to pass thwartships, unwinding between two horizontal drums some feet apart, under the two rubber fringes and under a sheet of carbon paper between it and them. Suitably interposed between the upper and lower paper strips would be a wooden block with a top face of hard rubber. All, being on deck, would be under cover.

The log line coming from the Vertical Log would be made to operate a device (c. f. "hatchet registration" above) which would deliver a mallet blow (from a mallet of hard rubber) in such manner as to print compass direction and turntable sector number on to the paper strip, for each chosen fraction of a sea-mile of water movement run past the ship.

The distance apart of the printings on the paper would be a measure of speed of water movement, and could be easily interpreted from a prepared scale made on a sheet of transparent celluloid, or taken by dividers from a scale prepared to suit. Speeds could be written on the paper strip at points midway between printings. The paper strip would have clock times already printed upon it, and could be anotated for time of high water and other times of interest. It would be necessary to let the paper strip be of such length (i.e., carried on drums suitably spaced) and pass at such speed as would achieve that successive printings were sufficiently separated to cater for a 6-knot stream. Certain relevant information as to the speed of turning of

the cup system of the Vertical Log has been given above, and it would seem desirable to provide gearing to achieve that the mallet blow were delivered for every 50 revolutions of the submerged cups (i.e., for every one-sixth mile of water movement). This would imply a strike each 20 minutes or so with a ½-knot stream, but the printings with a 6-knot stream would be very close, being made every 2 minutes or less. The implication is that the drums carrying the paper strip would have to be well spaced, and the clockwork have to move the paper fairly quickly.

Clearly, the best (because quickest and safest) method to adopt when writing actual current directions on to the strip would be to have a simple pasteboard model of the entire fit-up in the shore office. Then it would be easy to say at a glance what was the actual direction of current when, say, Sector 5 was printed opposite to 220° on the paper strip.

This suggested method of registration (also believed novel) would probably make little appeal to the fisheries researcher; he would usually prefer to get simple records of overall flow from a ball-dropping instrument (which records, be it noted, would also provide the tide researcher with masses of information on mileage reach of the tidal streams under all conditions).

Nevertheless there are occasions, as previous schemes of research attest, when the fisheries man wants to have discrete current records for particular brief periods: the type of registration just described (from now on referred to as "Typewriter Registration") would meet his needs ideally.

It has been described here although unlikely to be put into use until after the ball-dropping Vertical Log *cum* Drift Indicator instrument has been made and given long trials, because it would quite possibly be the easiest type of registration to adapt for use with an instrument of Vertical Log type made to work from an unattended buoy. To produce an instrument which will supply good results when so used is, of course, the ultimate aim, for, when data relating to more than brief periods and calm weather are required from places remote from lightships, there would be no present course open but to immobilize a ship to collect them.

There has been much talk in the past of measuring currents from unattended buoys, but far too little realism displayed. As is well known, observations can be satisfactorily carried out from Submarine Stations of Ekman type using certain types of instrument, and employing an indicator buoy for recovery purposes. That is good as far as it goes, but it may not be the wish to learn the water movements in the depths where the instrument escapes the trouble that comes from violent wave motion. What if one wishes to have results appropriate to ship draught depth?

If one seeks to employ an expensive and sensitive meter able to be left in use only under calm weather conditions, then a ship must stand

by to recover it with the onset of bad weather, which means that nothing is gained. Though there is little difficulty about getting results from fine instruments used suspended from surface buoys in sheltered waters (e.g., the Idrac meter used in the Seine estuary), it has to be frankly admitted that up to the present, no important amount of data has come from buoy-hung current-meters used in the open sea. If one accepts as a test of real usefulness the stern requirement that, before success can be claimed, it must be possible to show results relating to long periods and bad weather, then it seems that there are no worth-while methods of working from buoys at present extant.

The writer looks forward to the day when it will be possible to suspend an instrument of Vertical Log type from between two long baulks of timber anchored at both ends, the registering part to be of the "Typewriter" type described above. It surely will prove possible to do this (housing the registering parts in a small hutch built across the space between the two baulks dogged together). It would be necessary to flag the buoy and to light it. The effort would be justified only in the case of an instrument which gave results for the depth of interest (ship-draught depth), and which was specially designed to put on the barest minimum of registrations (amounting to spurious current) in response to buoy movement occasioned by waves. The future may show that the proposed instrument could be adapted to emit radio signals. So far no mention has been made of the important consideration of weed in the water. This is a matter which has very serious significance for fine instruments, but is one which matters not at all to the Vertical Log. This latter easily works free from weed and jelly fish, and is in any case so big that weed would usually collide with only part of the cup system. It is to be remarked that many parts of the instrument above proposed could be more or less home-made, and particularly is it to be mentioned that the cup system could be made even longer and heavier. This latter (the cup system) might one day (as proposed to the writer by Dr. Jacobsen) have substituted for it long lengths of semi-circular rain gutter iron such as is used for roof drainage. Such lengths could be borne on their own brackets secured at angles round wooden poles, the whole to be heavily weighted down below. There would seem much scope for improvization in the interests of cheapness.

At present the cup system (42 lb.), the suspension chain (33 lb.), and the plummet (88 lb.) of the Vertical Log weigh some 160 lb. in all.

Conclusion.

One can readily picture the perfect lightship from the viewpoint of the student of water movements in the sea. There would come from it simple and valuable continuous records of overall flow of water relating to all weathers and not restricted to a thin layer. From it would come, too, equally simple and useful data on wind mileage run towards various directions.

From the viewpoint of those concerned with matters navigational, interest would presumably attach to the masses of records forthcoming on the reach of the streams, to the fact that the data related (or could relate) to ship-draught depth, to the fact that information on water movement speed and direction *could* be radioed from the lightships on demand at any time, and to the fact that the installation of one proposed version of the instrument could result in the provision of precise data on water movement referred to hours of special interest. It seems possible to assume that the absence from the records of all but a bare minimum of spurious current due to registrations put on in response to ship movement would also be an attraction. Moreover, there is the fact that one modification of the instrument would be serving an apprenticeship (as it were) prior to adaptation for use from unattended buoys.

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The Inflow of Atlantic Water into the North Sea through the Orkney-Shetland Channel.

By

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THE following discussion of the inflow of Atlantic water through the passage between the Orkneys and the Shetland islands is intended as a contribution to the better understanding of the water economy of the North Sea. In course of time divergent views have arisen regarding this inflow. From his examination of the paths of a great number of surface drift-bottles Fulton (1897) was led to the conclusion that the inflow of Atlantic water into the northern North Sea takes place between the Orkneys and the Shetland islands as well as between the Orkneys and the Scottish mainland. On the basis of the Scottish researches in 1902, however, Helland-Hansen (1905) maintained that the inflow of Atlantic water takes place mainly between Shetland and Norway. From the Scottish investigations of the immediately ensuing years Robertson (1905, 1907, 1909, 1913) concluded that the predominant inflow takes place between the Shetland islands and the Orkneys. On the basis of the Scottish and Danish researches in the summer of 1924 Jacobsen and Jensen (1926) found an inflow between the Shetland islands and the Orkneys with a surface speed of about 2 cm./sec. These researches also showed that the water passing between the Orkneys and the Scottish mainland is of coastal origin. Mainly on the basis of his extensive surface drift-bottle experiments Tait (1930, 1932, 1934, 1937) arrived at the conclusion that the inflow to the North Sea occurs almost entirely eastward of the Shetland islands; van Riel (1936) states that this view is supported by the results of the Dutch researches in the northern North Sea during the years 1931 to 1935. The following dynamic treatment of the hydrographic sections from the Orkneys to the Shetland islands gives, however, evidence of an inflow to the North Sea through these sections of roughly the same magnitude as the inflow to the northwestern North Sea eastwards of the Shetland islands.

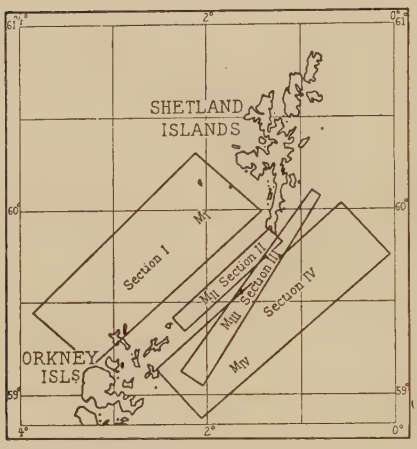

Figure 1. Location of Sections I to IV and of Current Maxima.

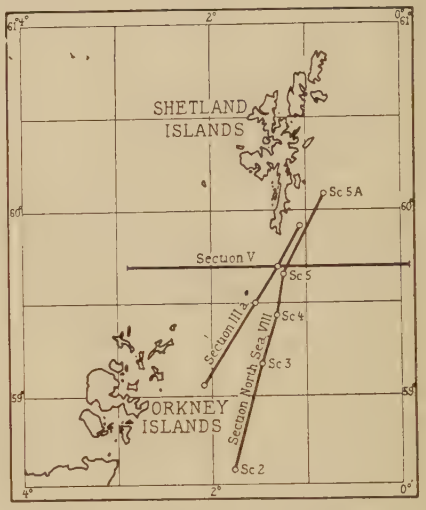

Figure 2. Location of Sections IIIa, V and North Sea VIII.

The material used for this paper is published in the *Bulletins Hydrographiques*, 1902 to 1939. The major part of the observations was collected by Scottish and Norwegian research vessels. Examination of the material showed that the majority of the hydrographic sections between the Orkneys and the Shetland islands may be grouped in four regions. For the sake of simplicity we will regard each group of sections as a single section which has been run several times and whose location is subject to fairly great variation from time to time. Thus each of these "sections" occupies a wide area, the limits of which are shown in Figure 1, where the "sections" are numbered I to IV. Furthermore we have included in our material the part of the section called "North Sea VIII" in the Bulletin Hydrographique which lies between the stations Sc2 and Sc5A (see Figure 2); we have also made use of a section shown in Figure 2 as Section V.

The stations in Section III were several times worked at the same places. These positions are indicated in Figure 2, in which the section is numbered IIIa. With the observations at these fixed positions we have constructed a mean section for each quarter of the year (Figure 3, A to D). The disposition of the isohalines and the isotherms in the section shows that the density of the water increases in the direction of the section from south-west towards north-east. There is thus a pressure gradient in this direction, and therefore an inflow of water into the North Sea must take place through the section. The same applies to Section North Sea VIII, of which Figure 4, A to D, gives mean sections for the four quarters of the year.

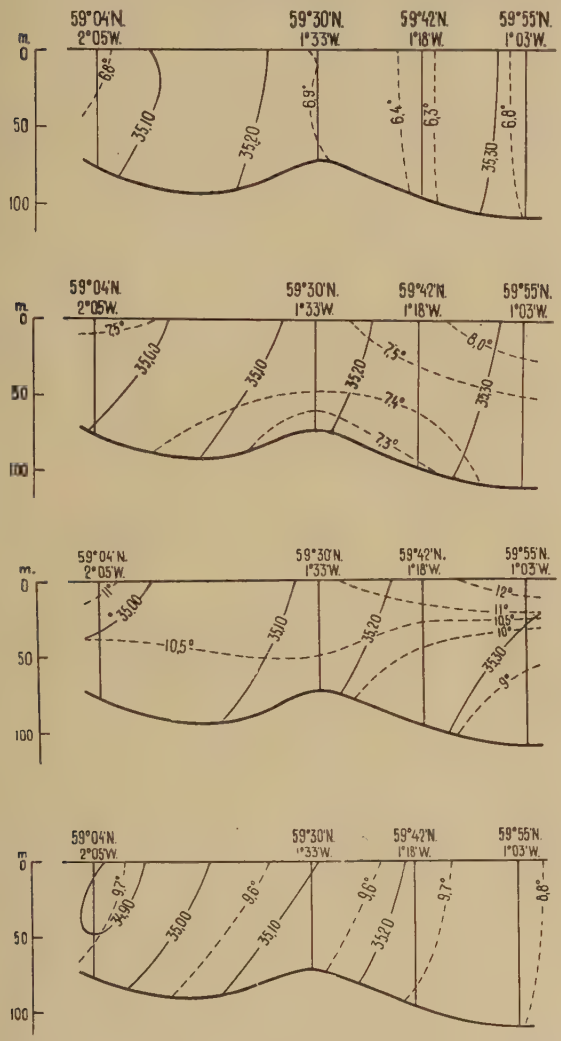

Fig. 3A: January—February—March.

Fig. 3B: April—May—June.

Fig. 3C: July—August—September.

Fig. 3D: October—November—December.

Horizontal scale
0 5 10 15 20
naut. miles

Figure 3. Section IIIa. Average quarterly Temperature (°C.) and Salinity (‰).

From the observations of temperature and salinity in the sections mentioned above the water movement perpendicular to the sections has been computed by dynamic calculations, made according to Jacobsen's method (1943, p. 33—34). The zero-surface used for each interval between two stations is the level surface at the greatest observational depth at the station with the least bottom depth. It was estimated that the choice of this surface as a zero-surface instead of the bottom of the sea would only slightly affect the result of the computations.

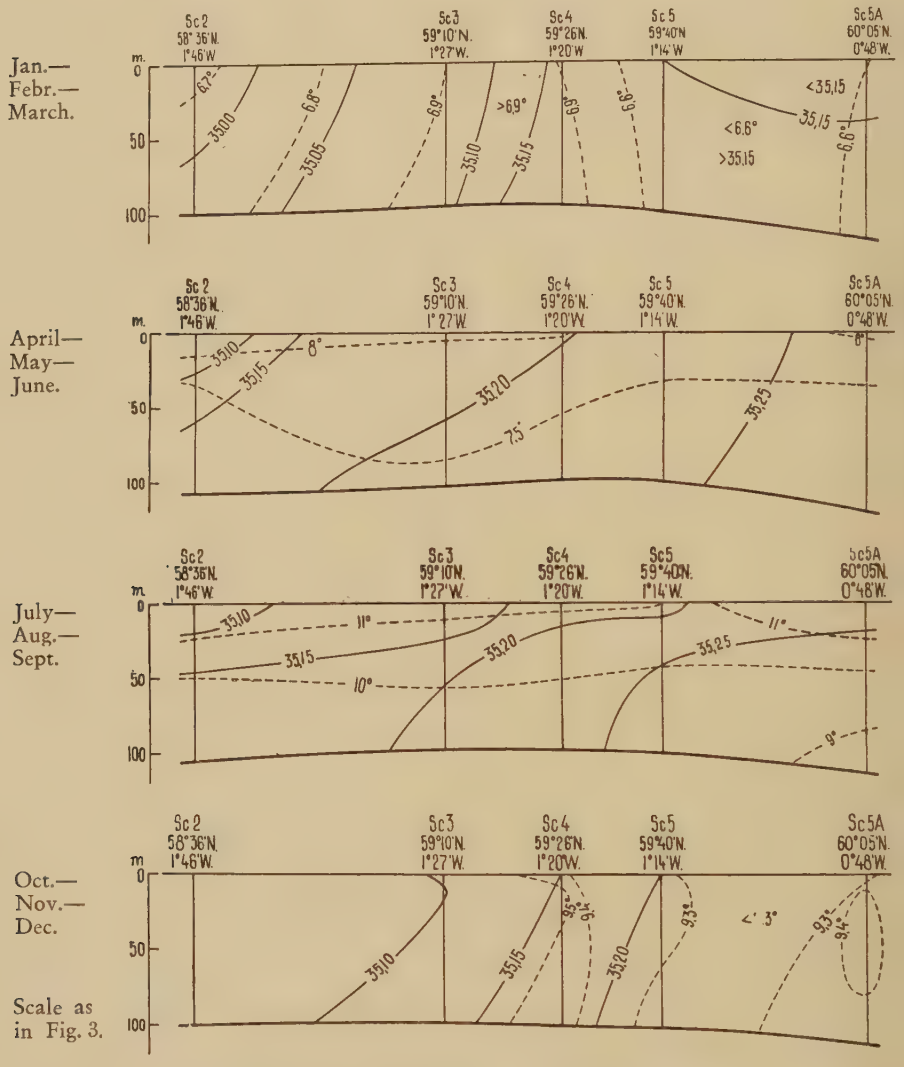

Figure 4. Section North Sea VIII. Average quarterly Temperature (°C) and Salinity (‰).

It appears from the calculations that the speed of the current is mainly the same throughout the uppermost layers of the water. Accordingly the speed of the surface current has been taken as the mean speed of the uppermost 10 metres. For each of the sections I to IV the distribution in the section of the velocity of the surface current perpendicular to the section is given graphically in Figure 5; such a curve has been constructed for each occasion on which the section was

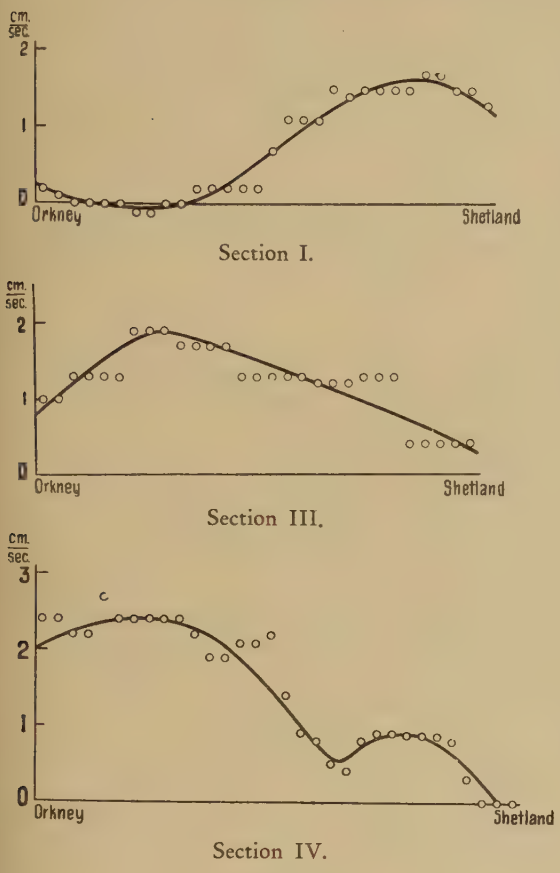

Figure 5. Surface Velocity perpendicular to Sections I to IV (see Figure 1), current to the south-east taken as positive.

worked, and the curves in Figure 5 are the mean curves. It will be seen from Figure 5 that the speed in the core of the surface current is about 2 cm./sec. for Sections I, III, and IV, whereas it amounts to about 3½ cm./sec. for Section II. This greater speed in Section II accords with the fact that this section is situated in the narrowest part of the channel.

The positions at which the surface current is maximal in Sections I to IV are indicated in Figure 1 by M_I, M_{II}, M_{III}, and M_{IV}. The line $M_I\ M_{II}\ M_{III}\ M_{IV}$ may be supposed to give the current direction. Thus the current is not perpendicular to the sections, but is directed south-south-eastward. Consequently the resultant current speeds are somewhat greater than indicated above. For Sections I, III, and IV the speed is slightly more than 2 cm./sec., for Section II about 4 cm./sec.

With the direction just found the current must have a component to the south of approximately the same order of magnitude as the component perpendicular to the passage. We will verify this by dynamic calculations for Section V, which runs east—west. This section has,

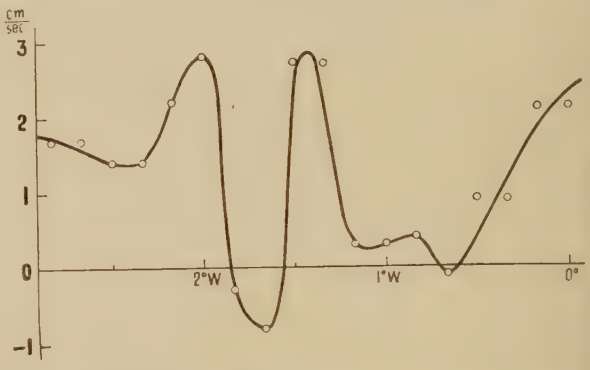

Figure 6. Surface Velocity perpendicular to Section V (see Figure 2), current to the south taken as positive.

however, been worked 4 times only. We have computed the surface velocity perpendicular to the section from the observations on each of these cruises. The current speed and its distribution in the section differ strongly from time to time. Figure 6 shows the variation of the mean surface velocity perpendicular to the section from place to place in the section. It appears from the curve that the maximum value of the velocity is 2 to 3 cm./sec.

The observations from Sections I to IV cannot be expected to give any information on seasonal variation of the inflow since they have been taken on relatively few occasions. Section North Sea VIII, on the other hand, has been worked more frequently. We have computed the surface velocity perpendicular to this section for each time the section has been worked. The means for each quarter of the year and for each interval between two stations are recorded in Table 1, which also gives the number of times that the section has been worked.

Table 1.

Surface current (cm./sec.) perpendicular to Section North Sea VIII (see Figure 2).

Period	Sc2	Sc3	Sc4	Sc5	Sc5A	No. of Inv.
Jan.—Feb.—Mar.	0·4	1·4	1·1	—0·1		8
Apr.—May—June	0·2	0·6	0·3	0·1		20
July—Aug.—Sep.	0·3	1·4	0·6	0·3		18
Oct.—Nov.—Dec.	0·4	2·2	1·6	0·3		8
Year	0·3	1·4	0·9	0·2		54

It appears from this table that the surface velocity perpendicular to the section in the core of the current is about 1½ cm./sec., i.e., of approximately the same value as for Sections I, III, and IV. Moreover, the table indicates that the current speed reaches its maximum in autumn, its minimum in spring. This accords with the view put forward by O. Pettersson (1906) that the influence of the Atlantic water in the neighbouring seas attains its maximum in late autumn.

The same section has been used for computation of the inflowing volume of water. The means for each quarter of the year are recorded in Table 2, in which the volumes are given for intervals between stations. Under the heading "Total" we have recorded the inflow over the entire section.

Table 2.

Inflow (km.^{3}/hour) through Section North Sea VIII (see Figure 2).

Period	Sc2	Sc3	Sc4	Sc5	Sc5A	Total
Jan.—Feb.—Mar.	0·04	0·08	0·06	0·00		0·18
Apr.—May—June	—0·01	0·03	0·01	0·03		0·06
July—Aug.—Sep.	0·01	0·05	0·04	0·10		0·20
Oct.—Nov.—Dec.	0·04	0·12	0·09	0·01		0·26
Year	0·02	0·07	0·05	0·04		0·18

The inflow thus averages about 0·2 km.^{3}/hour. The table shows that the inflow attains its maximum in autumn, its minimum in spring —which accords with the figures in Table 1.

We have also computed the volume of inflowing water for Sections I to IV. The averages are recorded in Table 3. This table also gives information as to the number of times these sections have been worked.

Table 3.

Inflow (km.^{3}/hour) through Sections I to IV (see Figure 1).

Section	I	II	III	IV	Average
Inflow of water	0·12	0·25	0·26	0·41	0·26
No. of inv.	12	6	25	16	

Finally we have computed the inflow through Section V. Only part of the section, from 0°55′W. to 2°35′W., was worked on all four occasions on which the section was run. The flow of water through this part of the section averaged 0·24 km.^{3}/hour. For the entire section from 0°05′E. to 2°55′W. the inflow amounts to 0·46 km.^{3}/hour, but this figure obviously includes water volumes which flow to the north of the Shetland islands and then bend to the south into the North Sea.

Summing up, we may say that according to the dynamic calculations an inflow into the North Sea of 0·2 to 0·3 km.^{3}/hour takes place through the Orkney-Shetland channel. Other calculations, the results of which will be published later, have shown that the flow into the north-western North Sea eastward of the Shetland islands is about 0·3 km.^{3}/hour. Thus the inflows by the two routes are of approximately the same magnitude.

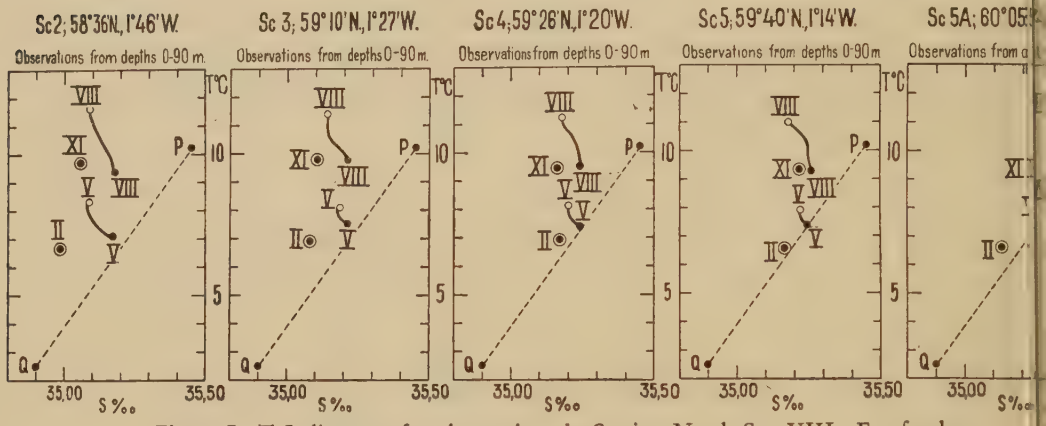

Figure 7. T-S diagrams for the stations in Section North Sea VIII. For further explanation see text.

We will now consider the water masses in the Orkney-Shetland area. For each of the stations in the part of Section North Sea VIII of which we have made use we have computed quarterly means of temperature and salinity for a number of depths. From these mean values we have prepared T-S diagrams for each station for the four quarters of the year (see Figure 7). The points representing the surface water are indicated by open circles, the bottom water by full circles. If the water at a station is so nearly homogeneous that the two circles would overlap, we have replaced them by two concentric circles. Each quarter of the year is indicated by the Roman figure for the middle month (February, May, August, and November).

It is seen at once that the water is almost homogeneous from surface to bottom, except in August when the summer heating is considerable; this influence is perceptible to a small degree in the diagrams for May also. The homogeneity is understood when it is borne in mind that very strong tidal streams exist in the area in question; at Fair Isle streams between 4 and 5 knots (200—250 cm./sec.) occur. These streams give rise to an intense mixing of the water masses.

The points P and Q in the diagrams indicate the water types $T = 10{\cdot}2°$, $S = 35{\cdot}45\ ‰$ and $T = 2{\cdot}5°$, $S = 34{\cdot}90\ ‰$ respectively. The former is found to a great extent in the Atlantic west of Ireland, the latter to the north and north-east of Iceland. As shown by Jacobsen (1943) the water in the Faroe-Shetland channel is a mixture of these two types, and mixtures of them will be represented in a T-S diagram by a point on the line PQ. It is seen from Figure 7 that for the quarters February and May the waters at stations Sc4, Sc5 and Sc5A are represented by points which lie almost on the line PQ, and the deviation from the line of the points for August and November may naturally be explained by the summer heating. At stations Sc2 and Sc3 however, an admixture of other water types has obviously taken place — in

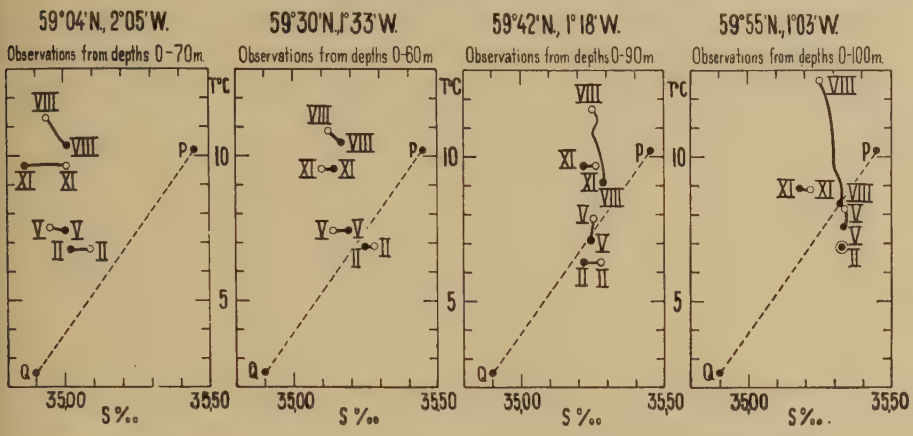

Figure 8. T-S diagrams for the stations in Section IIIa. For further explanation see text.

accordance with the fact that these stations lie further into the North Sea than the others.

Figure 8 gives in the same way average diagrams for the stations in Section IIIa. As far as the three northernmost stations are concerned the points may be said to lie approximately on the line PQ, when allowance is made for summer heating and winter cooling. As for the southernmost station (59°04′N., 2°05′W.), however, it is obvious that types are present other than those represented by the points P and Q.

The homogeneity of the water indicated in the T-S diagrams above is a characteristic feature of the Orkney-Shetland area. In order to get an idea of the extent of the homogeneity we have used the hydrographic card index of the International Council for an examination of all hydrographic stations in the area 59°—60°N., 4°E.—8°W.; 60°—61°N., 5°E.—6°W.; 61°—62°N., 3°E.—3°W. This area was divided into smaller areas each covering 1° longitude by ½° latitude, as shown in Figure 9, A to D. The number of stations is shown for each quarter of the year and for each area, and the percentage of stations at which the water was homogeneous is also shown. By homogeneous we will understand that the variation of temperature and salinity with depth — disregarding the uppermost 20 metres — does not exceed 1°C. for temperature and 0·1 ‰ for salinity. The figures show that in February the water is homogeneous over practically the whole area examined. In May we still have homogeneous water in a great area around the Orkneys and the Shetland islands while the heterogeneity spreads to the other parts of the area examined. In August the homogeneity is limited to a very narrow area between the Orkneys and the Shetland islands. In November it has again extended.

Finally we will consider whether the heating of the surface water which has been observed in many areas of the sea in the years after 1920. (see for instance S c h e r h a g 1937), can also be distinguished in the

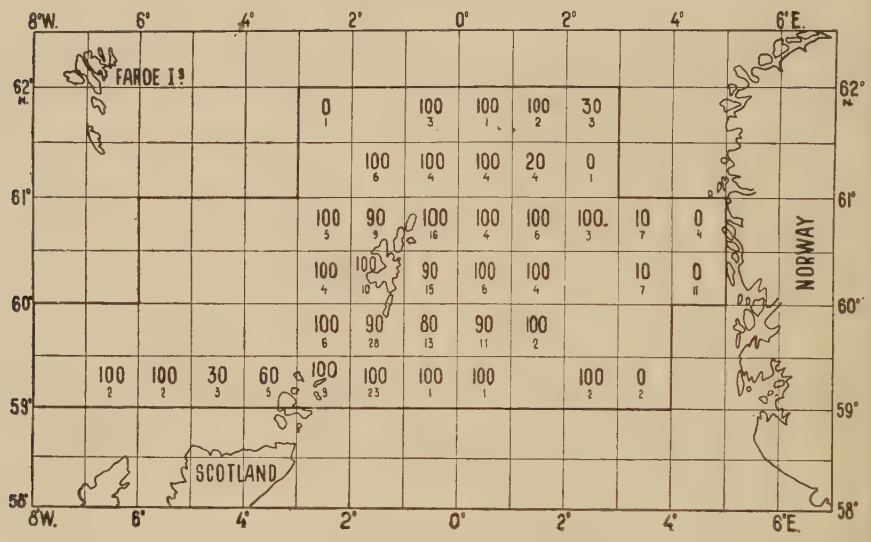

Fig. 9A: January—February—March.

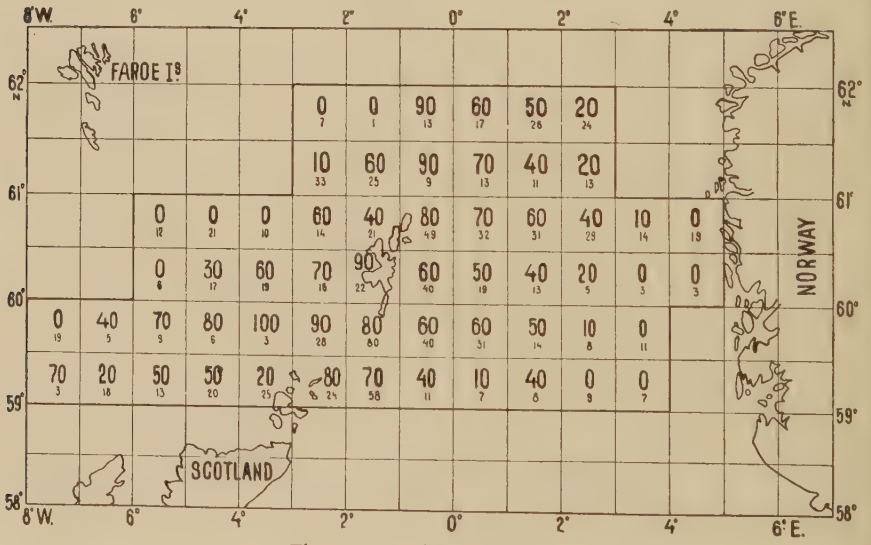

Fig. 9B: April—May—June.

Figure 9, A to D. Charts showing the degree of homogeneity of the water (large figures) and number of stations (small figures).

area in question. For this purpose we make use of the monthly mean temperatures of the surface water in the northern North Atlantic, published in the Danish nautical-meteorological annuals for the years 1900 to 1939. We will especially examine the area 59°—60°N., 1°—3°W.; this area just covers the passage between the Orkneys and the Shetland islands, and the observations from it are fairly numerous.

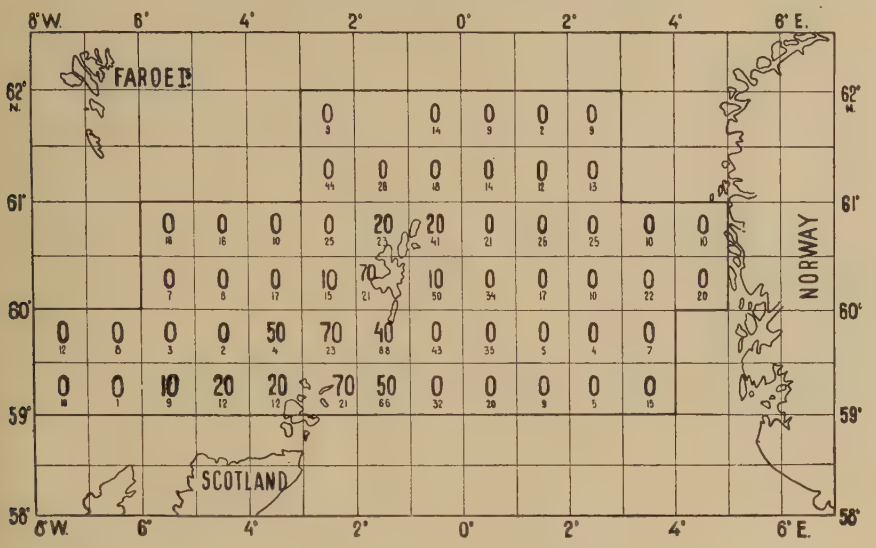

Fig. 9C: July—August—September.

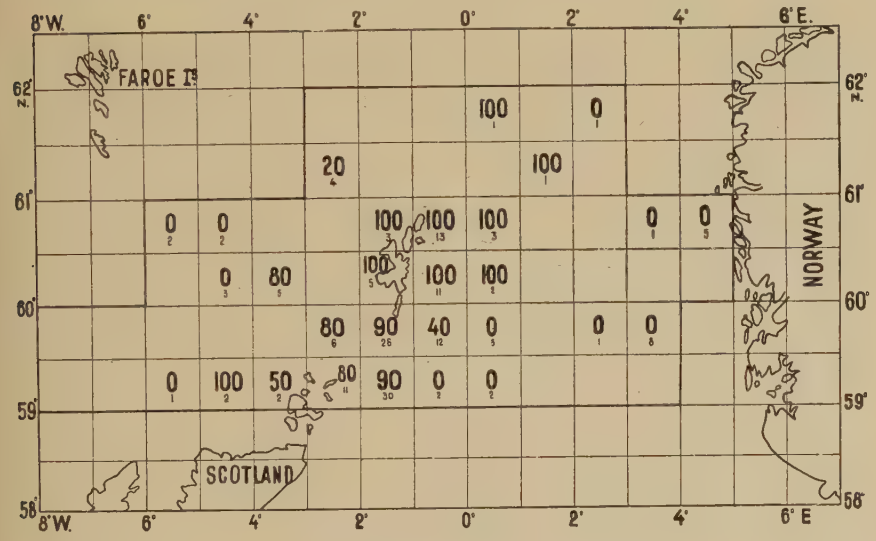

Fig. 9D: October—November—December.

Table 4 gives the computed five-year means of the surface temperature in this area; it must be noticed, however, that observations are lacking for some of the years between 1915 and 1919. It appears from the table that the temperature has constantly increased since 1920; between the first and the last periods in Table 4 the increase amounts to 0·6°C. A comparison of the periods 1900—1919 and 1920—1939 shows that the increase of the mean temperature from the former period to the latter is 0·3°C.

Table 4.

Five-year means of the surface temperature of the sea in the area 59°—60°N., 1°—3°W.

Period	1900-04	1905-09	1910-14	1915-19	1920-24	1925-29	1930-34	1935-39
°C.	8·8	8·9	9·1	(8·8)	8·9	9·1	9·3	9·4

In conclusion I should like to thank the head of the Hydrographic Service of the International Council for the Exploration of the Sea, Prof. Martin Knudsen, for the kind interest which he has taken in this work. I also want to express my sincerest gratitude to the late Dr. J. P. Jacobsen, the Hydrographer of the Council, for much help and encouragement during the work. I likewise beg to thank the Rask-Ørsted Foundation for valuable financial assistance.

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Records of Transparency in Gullmar Fjord.

By

N. G. Johnson and F. Koczy.

Records of transparency of the sea water have been made from the extremity of the observation pier at Bornö Station in Gullmar Fjord during the last half of 1945. The transparency meter constructed for the purpose measures the true transmission to green light with a centre of gravity at about 535 mμ (Schott a. Gen. filter VG 9, 2 mm. thick). The 1 m. horizontal light-way between the lamp-house and the photometer is screened from daylight by means of a tube open at both ends so as to allow a free flow of water through it. The light source is a lamp of 65 volts in the same circuit as another lamp of the same type placed in the laboratory, the circuit being fed by about 125 volts. Light from the latter lamp impinges on a small photo-electric element 20 cm. distant and provided with a 2 mm. green filter VG 9. This photo-electric element as well as that in the transparency meter is connected with a double recorder which registers each current 32 times an hour. In this manner variations in the lamp current are recorded together with the transmission. The transparency meter is lowered to every fifth metre and held for 10 minutes at each depth in order to secure at least 4 records. Usually measurements were carried out with some days interval, the reading taken in air with well cleaned windows being used as a standard.[1])

Isodiaphanes for transmission values of 40, 60, 70, 80, 85 and 90 % per m. are presented in Figure 1. The course of the isodiaphanes is characterized by the occurrence of clear water bodies at intermediate depths. In September water of nearly oceanic clarity showing above 90 % transmission entered between 15 and 20 m. On the other hand bodies of opaque water are also found in the diagrams, but more rarely.

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[1]) N. G. Johnson. Svenska Hydr.-Biol. Komm., N. S.: Hydrografi, XIX.

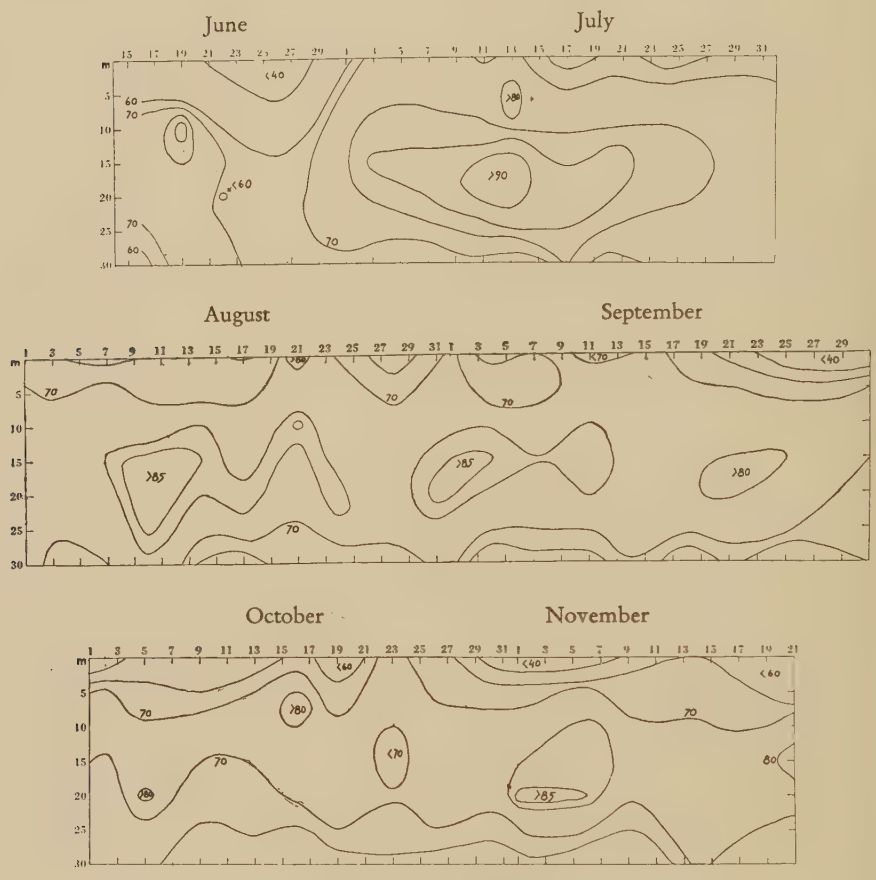

Figure 1. Isodiaphanes.

Judging from a comparison between isodiaphanes and isohalines the relationship between transparency and salinity seems to be rather complicated because the salinity increases with depth, whereas the transparency shows its maximum at intermediate depths. Yet in August, for instance, the clearest water lay between the 30 $^0/_{00}$ and 31 $^0/_{00}$ isohalines and a striking parallelism between isodiaphanes and isohalines can be established.

Mean values over the whole time for each depth have been calculated and are set out in Figure 2. The transparency curve exhibits a

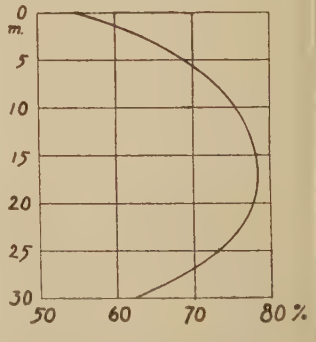

Fig. 2. Mean Values for June 15th to Nov. 21st.

smooth course rising from a surface value of 54·9 % to a maximum of 78·2 at 17 m. and then falling to 62·2 % at 30 m., or 3 m. above the bottom. The low transparency in the uppermost layers is caused by suspensoids, organic detritus, living plankton organisms or inorganic material, and by "yellow substance". The particles precipitate to some degree but are mostly carried away with currents.

On the other hand the decrease of transparency towards the bottom is due to sediment being whirled up by the turbulent motion of bottom currents. This influence extends at least up to 18 m. However, the effects of suspensoids originating from above and from below no doubt overlap at intermediate depths, so that it would be valuable to repeat the measurements at a depth greater than 33 m.

The Growth-Rate of Whitebait Herring of the North Wales Coast.

By

R. J. Daniel, D. Sc.

Introduction.

WHITEBAIT inhabit the coastal waters of North Wales, and references to samples caught in the fish weirs of the Menai Straits have been made by A. Scott, 1915, and Birtwistle and Lewis, 1925—26.

The latter obtained young herrings and sprats from the Penrhyn Weirs which lie between high- and low-water marks and are constructed of closely woven wicker-work.

The shape and disposition of these weirs have been described by Davis, 1937. They are primarily worked for salmon, although herring 2 to 7 years old are taken in November, and whitebait and other young fish throughout the year.

The power of retaining small fish is an advantage which the weir holds over certain types of commercial nets, and in the present investigations sprats have been taken down to 29 mm. in length.

When younger fish are snared as in the sample for 15th May 1939, the plotted length-frequency curve rises steeply from the lowest values to the mode, but this is not necessarily due to a selective catching power of the weir. There is a similar sharp rise to the chief mode in the sample for 10th January 1940, in which the lowest reading is for a herring of 92·00 mm., a length known to be easily contained by the weir since the majority of herrings and sprats recorded in this paper are below that length. The shape of the length-frequency curves, in fact, reflects certain habits of shoaling and is not due to selective fishing.

The weir fishes a definite area under conditions which are changed only by the differences brought about by the varying heights of spring and neap tides. Allowing events to supply the catch in this way has certain drawbacks. The fish may be few in number at any given time, and there may be irregular intervals between the catches; also it is not possible to know if all the fish entering the weir are finally trapped.

Nevertheless it is a "natural" method of sampling as opposed to the setting of nets in places where, from a knowledge of their habits, fishermen most likely expect the fish to be gathered at a given season.

Samples consisted of the total catch of whitebait except in certain cases of great plenty which made it necessary to accept only a representative part and allow the rest of the fish to escape through a trap in the weir.

The fish were received in good condition and it was possible to obtain scales when these were required for examination. The length measurements were taken from the snout to the end of the longest caudal fin rays and grouped to the nearest millimetre below the actual length (i.e., x mm. to x·9 mm., recorded as x mm.). The caudal fins of all the young herrings were normal.

There has been no further grouping or other form of smoothing because of the importance to the investigation of the actual values of modal points.

The figures below give a general picture of the abundance of young herrings and sprats in the whitebait, but there are variations from year to year. To take an example, the percentages for April, May, and June, 1940, may be contrasted with those for corresponding months in 1939. Such differences are due mainly to the varying times of influx of the new broods of 0-group herring and of young sprats.

Further, while herrings predominated on the whole, during 1939—40, Birtwistle and Lewis recorded a greater number of sprats in 1925, and this is true also for samples in 1941. These latter observations agree with the statement of Robertson, 1938, that in commercial whitebait from the North Sea, sprats are usually in the majority, although figures given by Hodgson, 1925, p. 28, show a high percentage of herring in North Sea whitebait for June—August.

	Herring	Sprats	Total	% Herring
1939				
May 5	1149	100	1249	92
June 6	621	46	667	93
June 14	835	17	852	98
June 19	406	162	568	71
July 4	313	78	391	80
July 18	267	33	300	89
August 2	332	40	372	89
September 1	89	94	183	48
September 13	148	58	206	72
September 29	71	925	996	7
October 13	29	861	890	3
October 27	169	436	605	28
November 10	169	175	344	49
November 24	232	6	238	97
December 14	137	12	149	92
December 18	108	44	152	71

	Herring	Sprats	Total	% Herring
1940				
January 10	192	10	202	95
January 29	147	9	156	94
February 24	163	3	166	98
March 11	175	17	192	91
April 8	30	193	223	13
April 22	4	370	374	1
May 2	5	523	528	1
May 14	9	548	557	2
May 30	2	283	285	1
June 21	62	314	376	16
June 24	881	351	1232	71
July 4	974	392	1366	71
1941				
July 1	862	3	865	99
July 22	443	706	1149	39
August 4	85	2170	2255	4
August 22	106	813	919	11
September 8	195	375	570	34
October 1	313	286	599	52
October 20	104	655	759	14
November 4	58	291	349	17
December 4	255	—	255	100
1944				
June 9	743	5	748	99
August 31	36	1005	1041	3

The Whitebait Herring.

Short accounts of young herring taken in Penrhyn Weirs, Menai Straits, during 1924—25, have been given by Birtwistle and Lewis, 1925, 1926.

An examination of the data presented by them shows that there was no increase in the mean length of herrings taken between 2nd July and 10th October 1924, and little advance in the general length distribution.

In fact, the authors remark that "the mean lengths of the samples do not show any very marked and steady increase as the season progresses" and conclude that there is little growth in young herring after June.

Such a conclusion is not supported by more recent work upon the growth of herrings in their first year, carried out by Ford, 1928, and Marshall, Nicholls, and Orr, 1939, and it is probable that the results obtained by Birtwistle and Lewis were due to the mixed nature of the young herrings they were sampling, an example of which may be taken from their own data. On 10th November 1924, 33 first-year herrings were caught in the weirs with a length range of 84 to 136 mm. and a chief mode at 105 mm. The

next day 60 first-year herrings from the weirs had a range of 64 to 141 mm. and the value of the mode was 70 mm.

The heterogeneous material that goes to make up the 0-group herring population in the particular area is reflected even more clearly in a sample of whitebait that was sent to me from the weirs on 15th May 1939.

The sample contained 1149 small herrings in their first year (Group 0); some of them had not yet completed their metamorphosis.

Upon plotting the length-frequency values it was clear, even after the application of methods for smoothing from the data irregularities that might be due to sampling and errors in measurement, that there were at least three broods of young herrings which were grouped, at this particular date, about the modal values of 47, 55 and 65 mm.

A second sample of whitebait which was received from the weirs on 6th June, twenty-two days later, contained 621 young herrings.

A comparison of the length-frequencies of the two samples shows that the smoothing mentioned above was not fully justified. If the major irregularities in the two graphs are regarded as modal points which reflect the make-up of the actual composition of the young herring samples, then the following result is obtained when the principal mode of the first sample is placed in line with that of the second sample.

	Modal Values in mm.	
Sample 15.5.39	Sample 6.6.39	Difference in mm. for 22 days interval
45	54	9
47	56	9
50	58	8
52	61	9
55	65	10
58?	69	11
65	74	9

Possible modes at ends of the distributions are not included because of the few individuals involved.

In addition, the two graphs have the same general shape which is made up of a principal mode situated near the lower end of the length-frequencies and a consequent wider dispersion above this value, with secondary modes that decrease in height as the upper limit of the distribution is approached

Another point emerges from these modal values. Since it has taken approximately three weeks for young herring to grow from 45 mm. to 54 mm., and from 55 mm. to 65 mm., it is possible that the hatching of the broods, which are represented in the first sample by the modes 45 mm. to 65 mm., may be contained within a period of about six weeks.

It was apparent from this examination of the first influx of 0-group herring for 1939 that there was much less confusion in the mix-

ing of different broods represented in the samples than Birtwistle and Lewis, 1925—26, found in the years 1924 and 1925.

It was decided, therefore, to continue examination of whitebait herring from the weirs, obtained as nearly as possible at fortnightly intervals, until the time when the first "winter" ring was clearly laid down in the scales.

A general increase in the length of the herrings was shown throughout the series and it follows that this upward trend was shared by such central values as the mean, which was used by Birtwistle and Lewis, for purposes of comparison.

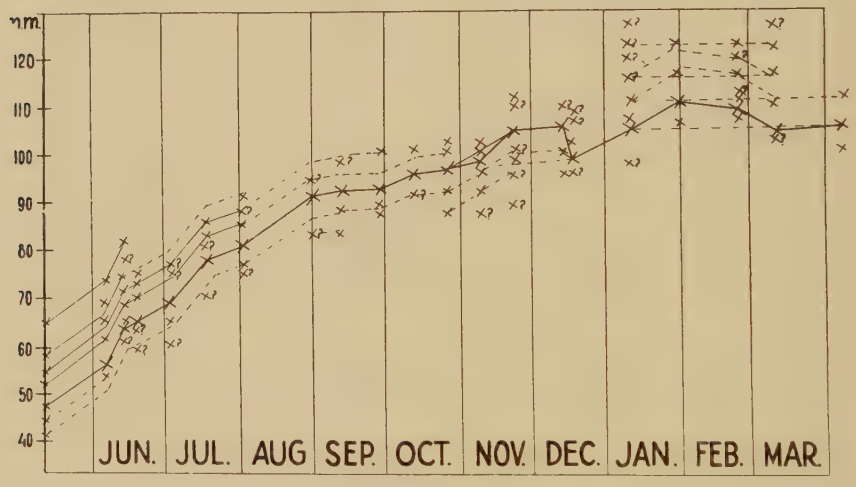

Figure 1.

The disposition of the length-frequency graphs for the first two samples has already been described and an attempt may be made to follow the history of the modes through the latter samples.

Those irregularities in the length-frequencies which might be assumed to represent modal points have been plotted in Figure 1 a query being placed behind certain of the points which might equally be regarded as due to irregularities in sampling. The following premises were then considered, following on the comparisons already made between the first two samples. First that the principal modes of the samples were in a common line of descent; this gives the main curve in Figure 1. Second that the broods of fish represented by modes of the first sample would show a similar rate of growth to that of the brood represented by the principal mode since there is a common increase of about 9 mm. between corresponding modes of the first and second samples.

Lines parallel to the graph joining the principal modes were therefore drawn through the modes of Sample 1 (15th May 1939) since the

lines are close enough to be only slightly affected by any convergences that may be due to the shape of the graph.

There is little doubt of the relationship between these parallel graphs and the plotted modal points for the first six samples, except perhaps in the cases of the extreme modes of 42 mm. and 65 mm.

A prominent mode appears at 65 mm. in the sample for 4th July 1939, but this does not interfere with the excellence of the fit between curves and points, and the mode itself can be traced to the mode at 42 mm. in the first sample, which was regarded as a doubtful case because of its nearness to the one end of the length-frequency curve. It

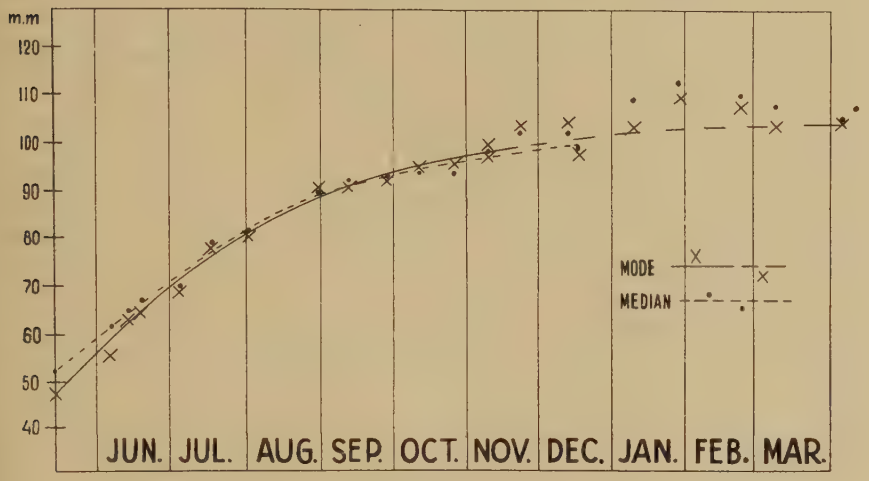

Figure 2.

is true, also, that in the sample for 4th July the modes at 75·0 mm. and 77·0 mm. have been marked as doubtful but the use of them is justified by the following sample for 18th July in which corresponding modes (at 83·0 mm. and 86·0 mm.) are clearly defined.

During this progress, however, the shape of the graphs of length-frequencies for the samples have undergone some changes.

The unsymmetrical nature of the graphs for the earliest samples becomes less pronounced; that is, the samples are less heterogeneous, and this change, foreshadowed in the samples for July, has its full effect during the period from the beginning of August until the end of November 1939.

Irregularities in the graphs also become subdued and although some of them may be traced to secondary modes they are not sufficiently important to disturb the general length-frequency distribution.

Consequent upon the changes enumerated, the values of the principal mode and of the median lie close together during the period from early July to November 1939. There is also less dispersion of the

distributions and this is not due solely to the comparatively small numbers of herrings taken in each catch during this period.

The median rather than the mean is mentioned above because, apart from its virtues when there are scattered or atypical members in the sample, it is the central value used by Ford, 1928, when discussing the growth-rate of first year herring at Plymouth, and later by Marshall, Nicholls, and Orr, 1939, in similar work on Clyde herrings.

An estimation of its value, therefore, is useful in a comparison of growth-rates in the areas concerned and consequently the median for each sample has been inserted in Fig. 2.

The evidence examined so far justifies the premise that the principal modes have a common lineage, but it meets with a serious challenge in the remaining samples dated from November 1939 to April 1940.

The curve of growth representing the principal modes, and the median, now becomes somewhat irregular (Fig. 1) and if the values are accepted they indicate a period of quickening growth in November and of further growth from December to January, a position that is complicated by a sudden drop in values between samples for 14th and 18th December.

It is necessary, however, to proceed with some caution when weighing up the evidence presented by the samples. The general shape of the length-frequency curves are somewhat like those at the beginning of the series, but the distribution is more widespread so that the curves are flatter in contour and more regular in outline. Under such conditions the addition or subtraction of one or two fish from one length-group to another, as may well happen in sampling, will cause gross alteration in the position of modal values, particularly when the samples are not large, as in the present case.

Further, there is little doubt from the position of the modes that some of the fish, which were grouped about 58 mm. and 65 mm. in the first samples and have been little in evidence subsequently, have again appeared (values above 115 mm. can only be explained in this way) so that the median is of little value in such a heterogeneous sampling.

Central values, therefore, are hesitant from November 1939 onwards and do not in themselves clearly indicate the trend of the annual growth-curve.

There is other evidence, however, which has a bearing upon growth during this period of the year and it is found in an examination of the herring scales.

It is accepted, in general that the rings formed in the upper layer of herring scales indicate a period of minimum growth which has been referred to as the "physiological winter". Supporting evidence has been derived from observations on adult herrings and is based mainly

upon statistical methods, although similar conclusions have been reached from studies of scale structure.

In the sample for 24th November scales of 40 out of 232 herrings were edged with a transparent band. This is the "A" condition as defined by Hodgson, 1925, and was the first indication of the laying down of a winter ring.

Later samples showed an increase in the proportion of fish with scales in the A condition, except 18th December, and all the herrings for 24th February 1940 had scales in the A condition.

Completed rings were doubtfully present in a few fish as early as January. It is difficult to detect the presence of a newly formed ring on these young fish and definite rings were not recognized until the sample for 8th April 1940.

The laying down of the first ring, then, was concerned with just those samples, between November 1939 and April 1940, that are under discussion. It is interesting to note, therefore, what manifestations of growth the scales show during this period. Lee, 1920, states that the striated upper layer and the laminated lower layer of the herring scale grow together during the height of the season, but that later the lower layer gains on the upper and leaves a transparent edge. This description applies to the scales of 0-group herrings from North Wales.

In June the striations reach the edge of the scale; by December scales of larger fish in the samples are showing a clear edge. From January to March striations of the upper layer are beginning to cover the clear winter edge, and this is taken to represent growth in the layer because of the attenuated appearance of the end of the striae. In May striations are again at the edge of the scale. Since, on the whole, the growth of the scale is proportional to that of the fish the emergence of the basic portion as a clear edge from November to February does indicate that some growth is taking place at this time although the general evidence that it is not great may be accepted.

It is this minimum growth period from November to May which is represented in Figure 1 by values which are not in harmony with those of the rest of the curve. There is little doubt that the graph should be approaching the horizontal in a natural continuation of its general contour from May to December 1939.

That it does not do so is due to confusion in the samples drawn at this time from a heterogeneous population. The apparent backward growth in December is probably due to the immigration of herring from a later spawned group. In contrast, the forward growth indicated in November and the beginning of December may have been due to an influx of larger fish.

From a consideration of the secondary modes in these samples it is possible to plot two practically horizontal lines in Figure 1, one from 24th November to 18th December 1939 and the other from 10th January to 4th April 1940. The lines, however, are at different levels

(98 mm. and 105 mm.) so that it is not possible to connect both of them with the main curve of growth. In Figure 1 lines parallel to the one at 105 mm. are also indicated at 111 mm. and 122 mm.

The thick dotted line in Figure 2 continues the sweep of the main curve and having regard to the evidence from the scales, is suggested as the probable trend of growth during the winter. It is found that the broken line coincides with the line at 105 mm. mentioned above.

A relationship may be traced between a curve such as that represented in Figure 2 and the rate at which the basic structure of a herring scale is laid down.

P a g e t, 1920 discussed the lamellar portions of the lower layer and concluded from their disposition that there is "a clear demonstration of periodicity in the growth of the scale; first, a vigorous growth with corresponding broad outcrops of the lamellae; later a slackening of the growth-rate is indicated by gradually narrowing outcrops; finally probable total cessation of growth to be followed in its turn by vigorous growth in the ensuing years".

It may be noted here that while P a g e t apparently favours total cessation of growth, he is more cautious later in the same paper when he declares that "the transparent ring of the lateral scales of herring does in fact mark a period of minimum growth".

The above description of the lamellae contains the implication that they are laid down in approximately equal intervals of time. Accepting this, it is possible to construct a general curve of growth for a herring scale in the following manner.

The lamellae show alternate light and dark bands under polarized light and measurements may be made of the distance from the centre of the scale to the outer edge of each light lamella.

This may be done to suit the present purpose by using photo-micrographs of herring scales under polarized light. Instances of these are given in Figure 14, Plate III, in a paper by S a v a g e, 1919 and Figure 14 Plate IV accompanying the Report of E i n a r L e a, 1918, on "Age and Growth of the Herring in Canadian Waters".

If the measurements thus taken are plotted at equal time intervals and to a suitable scale, it will be seen that the graph obtained by joining the plotted points is of the same general order as the curve in Figure 2.

The broods of herring so far discussed were sampled until 30th May 1940. There were less than ten herrings in each sample from 8th April to 30th May; they were all 100 mm. or more in length and the scales had either a clear edge or a definite ring laid down.

Herrings of the following 0-group were not sampled in the weirs until 21st June, and circumstances did not allow samples to be obtained after 4th July in 1940.

It was possible, however, to obtain whitebait from 1st July to 4th December 1941, and a further two samples in 1942.

There is sufficient data to compare the median and modal values of young herrings caught in 1941 with those of 1939 and early 1940.

At corresponding dates in the year the median and mode have, in all cases, a lower value in 1941 than in 1939. In fact, except for the sample 1st July 1941, the principal modes lie below the lowest possible modes marked in Figure 1 for 1939.

Further the curve rises less steeply, so that not only was there a run of smaller fish being sampled in 1941, but these fish grew less rapidly during the course of the year.

Consequently by December, in spite of a sudden rise in the curve during that month, the mode was only 85 mm. as compared with 100 mm. in 1939.

The two samples for 1942 also give lower length values than corresponding dates in 1939.

From the data collected, therefore, it may be stated that the size of 0-group herring when they appear close inshore, as well as the subsequent rate of growth, are not necessarily the same from year to year.

The modal values obtained for each month from smoothed curves, and the monthly increments in millimetres for 1939 and 1941 are given in the following table:—

Table 1.

Comparison of Growth of 0-Group Herrings from North Wales, 1939 and 1941; based on smoothed values in millimetres.

	1939		1941	
	Mode	Increment	Mode	Increment
July 1st	69·7		60·0	
		11·1		8·5
August 1st	80·8		68·5	
		8·2		7·0
September 1st	89·0		75·5	
		5·2		5·5
October 1st	94·2		81·0	
		3·3		2·5
November 1st	97·5		83·5	
		2·2		2·0
December 1st	99·7		85·5	

Comparison of Rates of Growth with that of Young Herrings in other Areas.

The growth-rate of the whitebait herring from Penrhyn Weirs, Menai Straits, may be compared with that of other areas from which workers have recorded growth at short intervals of time before the first scale ring is laid down.

Ford, 1928, deduced the growth-rate of 0-group herrings from the Tamar and Lynher, Plymouth, by smoothing the graphs of the

median body-length for each sample. From the smoothed values were obtained the monthly increments of the median total length. These results may be compared with the ones obtained for North Wales herring in 1939, when the data was most complete and length values the highest of the series.

The accepted modal values for the Menai Straits have been smoothed in Figure 2 and so also have the median values. The value of the mode and median are very similar in samples from the end of June to December 1939. The median values from the Menai Straits for other periods are less important because of the pronounced heterogeneity of the samples.

It will be seen that whereas the median values found by Ford are similar to those for the Menai Straits at the beginning of the series in June, the rate of monthly increment is much higher. There is a decrease in the amount of growth during each succeeding month in both cases, but whereas the Tamar and Lynher herrings have reached 126 mm. and 129·5 mm. respectively by December, the Menai value for the median and mode is not more than 100 mm. There is a quicker growth-rate in the Tamar herrings over the same period of the year, although they are no smaller at the beginning of the period and therefore do not need to "catch up" on the Menai Straits fish.

Marshall, Nicholls, and Orr, 1939, in summarizing the growth-rate of the Clyde inshore herring from metamorphosis to the formation of the first winter ring state, on page 438, that the median weekly increment during the growth period, 26th May to 7th October, is 3·5 mm. which is compared with that of 3·2 mm. deduced by them from Ford's figures for the Tamar.

Upon such a basis, which has a limited value since actually the rate of growth is steadily decreasing, the weekly increment of the Menai herring from 1st June to 4th October is 2·2 mm.

The Menai 0-group herring have also a different growth-rate from that of the Clyde young offshore herrings according to the data of Marshall, Nicholls, and Orr, which include a median length of 39 mm. for 1st June and of 55 mm. for 1st July.

The smoothed graphs from which the monthly increments of the Plymouth and North Wales fish were obtained represent a small but steady decrease in the growth-rate as they proceed along the time axis.

The smoothed graph given for the Clyde herrings has more the appearance of a straight line (see Figure 3, Marshall, Nicholls, and Orr). This effect is partly due to the ratio of the length and time axes in the figure, but there is not the same decrease in the growth-rate with time as in the other cases. This is reflected in the figures included here in Table 2, although it is not advisable to stress the value of these, because they have been pricked off from Figure 3, mentioned above, which, from the necessity of reproduction, is on a small scale.

When the time is reached for the laying down of the first ring in the scales, therefore, the whitebait herrings from North Wales were shorter than the young herrings from Plymouth and the inshore young herrings from the Clyde.

Examining in Figure 1 the somewhat irregular principal modes from the later part of November 1939 until the end of April 1940, when the winter edge of the scale is already formed, none of them is

Table 2.

Comparison of Growth of 0-Group Herring from North Wales, 1939, Plymouth and the Clyde, based on smoothed values in millimetres.

	N. Wales (Daniel)				Tamar, Plymouth (Ford)		Clyde Inshore (Marshall, Nicholls & Orr)	
	Median		Mode		Median		Median	
	Total Length	Increase	Total Length	Increase	Total Length	Increase	Total Length	Increase
June 1st	59·6		55·7		58·3		—	
		11·8		14·0		19·8		
July 1st	71·4		69·7		78·1		83·0	
		10·6		11·1		18·7		17
Aug. 1st	82·0		80·8		96·8		100·0	
		7·6		8·2		15·2		14
Sept. 1st	89·06		89·0		112·0		114·0	
		4·4		5·2		8·1		16
Oct. 1st	94·0		94·2		120·0		130·0	
		3·5		3·3		3·5		3·0
Nov. 1st	97·5		97·5		123·6		133·0	
		3·0		2·2		2·4		
Dec. 1st	100·5		99·7		126·0		—	

represented by a length of more than 110 mm. and the smoothed curve gives values between 100 and 110 mm. Further, the few fish for late April and May 1940, each with completed first rings, show much the same length values; seventeen out of twenty lie between 105 mm. and 115 mm.

The highest value for a secondary mode which may be accepted as genuine is 120 mm. (29th January 1940) and it is probable that this has no connexion with any of the modal values in the first sample for May 1939.

The Origin of the Whitebait Herring.

It will not be possible to trace directly the origin of the whitebait herring described in this paper until more is known of their history previous to entering the weirs.

In the meantime it may be assumed that the fish dealt with in 1939

Length Frequencies of Young Herring

In 5 mm. Groups. e. g., 40 mm. = 40 1

Date	35	40	45	50	55	60	65	70	75	80	85	90
1939												
May 15	—	57	398	254	215	120	79	11	—	—	—	4[1]
June 6	—	—	7	60	198	175	114	39	20	5	—	—
June 14	—	—	—	13	85	350	255	116	13	2	—	1
June 19	—	—	—	—	35	112	99	76	45	27	6	4
July 4	—	—	—	—	5	54	118	102	29	2	—	2
July 18	—	—	—	—	1	1	5	48	98	88	21	1
Aug. 2	—	—	1	1	1	—	1	7	72	169	70	8
Sept. 1	—	—	—	2	2	—	2	1	3	12	27	38
Sept. 13	—	—	—	—	—	—	1	—	—	9	28	86
Sept. 29	—	—	—	—	—	—	—	—	—	2	18	34
Oct. 13	—	—	—	—	—	—	—	—	1	2	4	9
Oct. 27	—	—	—	—	—	—	2	3	3	10	26	48
Nov. 10	—	—	—	—	—	—	—	—	—	1	7	35
Nov. 24	—	—	—	—	—	—	—	—	1	1	9	14
Dec. 14	—	—	—	—	—	—	—	—	—	—	3	7
Dec. 18	—	—	—	—	—	—	—	—	—	—	6	17
1940												
Jan. 10	—	—	—	—	—	—	—	—	—	—	—	2
Jan. 29	—	—	—	—	—	—	—	—	—	—	—	3
Feb. 24	—	—	—	—	—	—	—	—	—	—	—	4
Mar. 11	—	—	—	—	—	—	—	—	—	—	—	5
Apr. 8	—	—	—	—	—	—	—	—	—	—	—	—
Apr. 22	—	—	—	—	—	—	—	—	—	—	—	—
May 2	—	—	—	—	—	—	—	—	—	—	—	—
May 14	—	—	—	—	—	—	—	—	—	—	—	—
May 30	—	—	—	—	—	—	—	—	—	—	—	—
June 21	—	—	—	4	9	12	30	5	2	—	—	—
June 24	39	115	235	286	143	45	14	4	—	—	—	—
July 4	—	3	52	252	344	184	90	39	8	1	—	1
1941												
July 1	—	—	1	14	203	455	142	36	9	2	—	—
July 22	—	—	—	—	17	96	235	85	9	—	1	—
Aug. 4	—	—	—	3	15	17	30	19	—	1	—	—
Aug. 22	—	—	—	—	2	5	22	46	23	4	3	1
Sept. 8	—	—	—	—	—	7	17	60	80	22	8	1
Oct. 1	—	—	—	—	—	—	2	16	101	134	47	9
Oct. 20	—	—	—	—	—	1	—	4	29	34	27	6
Nov. 4	—	—	—	—	—	—	5	18	17	14	2	2
Dec. 12	—	—	—	—	—	—	—	—	4	31	50	64
1942												
June 9	6	25	73	232	225	102	42	18	9	9	2	—
Aug. 31	—	—	—	1	—	5	9	11	5	3	1	1

ırhyn Weir, Menai Straits, North Wales.

dicates additional Fish with one-ringed scales.

105	110	115	120	125	130	135	140	145	150	155	Total Number of Herrings	Date
												1939
2	4[2])	2	—[2])	2[1])	—[1])	—[1])	—	—	—	—	1161	May 15
2	1	—	—	—	—	—	—	—	—	—	621	June 6
—[1])	—	—	—[1])	—[1])	—	—	—	—	—	—	838	June 14
2	—	—	—[2])	—[1])	—[1])	—	—	—	—	—	410	June 19
—	—	—	—	—	—	—	—	—	—	—	313	July 4
—	—	—	—	—	—	—	—	—	—	—	267	July 18
—	—	—	—	—	—	—	—	—	—	—	332	Aug. 2
—	—	—	—	—	—	—	—	—	—	—	89	Sept. 1
1	—	—	—	—	—	—	—	—	—	—	148	Sept. 13
—	—	—	—	—	—	—	—	—	—	—	71	Sept. 29
—	—	—	—	—	—	—	—	—	—	—	29	Oct. 13
3	4	2	1	—	—	—	—	—	—	—	169	Oct. 27
18[1])	9[1])	3	1	—	—	—	—	—	—	—	172	Nov. 10
40	27	8	5	—[1])	—	—	—	—	—	—	232	Nov. 24
33	13	4	2	—	—	—	—	—	—	—	137	Dec. 14
16	6	1	3	1	—	—	—	—[1])	—	—	108	Dec. 18
												1940
43	34[1])	30	23	9	3	1[2])	—	—	—	—	191	Jan. 10
24	33	26	13[1])	8	4	3	1	2	2	1[1])	147	Jan. 29
41	33	28	9[1])	11	3	1[1])	—	—[1])	—	—	162	Feb. 24
46[1])	24[1])	25	12	7	2	4[1])	—	2	—	—	175	Mar. 11
10	5[1])	1	—	—	—	—	—	—	—	—	30	Apr. 8
—	3	—	—	—	—	—	—	—	—	—	4	Apr. 22
—[2])	—[1])	—[1])	—	—	—	—	—	—	—	—	5	May 2
—[3])	—[1])	—	—	—	—	—	—	—	—	—	9	May 14
—	—[2])	—	—	—	—	—	—	—	—	—	2	May 30
—	—	—	—	—	—	—	—	—	—	—	62	June 21
—	—	—	—	—	—	—	—	—	—	—	881	June 24
—	—	—	—	—	—	—	—	—	—	—	974	July 4
												1941
—	—	—	—	—	—	—	—	—	—	—	862	July 1
—	—	—	—	—	—	—	—	—	—	—	443	July 22
—	—	—	—	—	—	—	—	—	—	—	85	Aug. 4
—	—	—	—	—	—	—	—	—	—	—	106	Aug. 22
—	—	—	—	—	—	—	—	—	—	—	195	Sept. 8
—	—	—	—	—	—	—	—	—	—	—	313	Oct. 1
—	1	—	—	—	—	—	—	—	—	—	104	Oct. 20
—	—	—	—	—	—	—	—	—	—	—	58	Nov. 4
14	7	2	1	—	—	—	—	—	—	—	255	Dec. 12
												1942
—	—	—	—	—	—	—	—	—	—	—	743	June 9
—	—	—	—	—	—	—	—	—	—	—	36	Aug. 31

were spawned towards the latter end of 1938; since there is a very little evidence of spring spawning herrings in the Irish Sea.

Adult herrings frequent this part of the coast, and there are scattered records of small numbers of them that have been caught in the bays by trawlers during the months of November and December.

Moelfre Bay is fished in these months each year by anchored nets and Birtwistle and Lewis, 1924, examined adult herrings from catches made in this way. Four samples with a total of 320 herrings were obtained during November 1923. The gonads were in Stage V or Stage VI; that is, the herrings were about to spawn or had already spawned. A further sample received on 21st January 1924 from the same fishing was made up of spents or recovering spents.

Similar conditions of the gonad were found in 250 adult herrings taken from the Penrhyn Weirs during the same period.

These are indications of a spawning ground in the area of capture which Birtwistle and Lewis, 1924, suggest "is probably a continuation of the ground south and south-west of the Isle of Man, which was yielding fish in a similar stage of maturity and of similar age composition a month earlier."

The lengths of the Moelfre and Isle of Man herrings were found to be the same for corresponding age-groups, and the percentage-frequencies in each age-group were of the same general order in each case.

Since the distance from one ground to the other is 40 miles there is justification for assuming that the Moelfre herrings are herrings from the Isle of Man shoals which were backward in their state of maturity in September.

It is of direct interest, therefore, to examine the values of the calculated first year growth (l_1 value) obtained from the scales of these late spawning fish and from the scales of Isle of Man herring to which they appear to stand in close relationship.

The scales of the Moelfre herring gave a modal l_1 value of 12·5 cm. This, in the method of measurement used by Birtwistle and Lewis, represents values between 12 and 13 cm.

Observations have also been made upon the annual growth of herrings from the Isle of Man region. It was found by Birtwistle and Lewis, 1924, that in 1923 the l_1 readings showed a wide range of values (70 to 170 mm.) and although there was no definite bimodal grouping, they state that the data "tends to show a grouping round about 100 mm. and again about 130 mm. as a first year's growth."

Working on Isle of Man herrings in later years (1934—36) Hsüeh, 1939, came to a similar conclusion. He found that the l_1 distribution was from 80 to 180 mm. and that the frequencies were grouped about 100 mm. and 130 mm.

It is true that Hsüeh was dealing mainly with inshore herring, but he stated that the scales of offshore herrings gave similar readings.

Table 4.

Date	Unsmoothed Value (mm.) of Mode	Median	Total Number of 0-Group Herrings
1939			
May 5	47	52·1	1150
June 6	56	61·1	621
June 14	63	64·6	835
June 19	65	66·9	406
July 4	69	69·4	313
July 18	78	79·0	267
Aug. 7	81	82·1	332
Sept. 1	91	89·5	89
Sept. 13	92	92·4	148
Sept. 29	92 (93)	92·7	71
Oct. 13	95	94·5	29
Oct. 27	96 (92)	94·3	169
Nov. 10	98 (100)	98·6	169
Nov. 24	104 (105)	102·9	231
Dec. 14	105	103	137
Dec. 18	98	99·9	107
1940			
Jan. 10	104	110·2	188
Jan. 29	110	113·6	145
Feb. 24	108	110·8	159
March 11	104	108·9	169
April 8	105	105·3	29
April 22	—	110·3	4
May 2	—	—	0
May 14	—	—	1
May 30	—	—	0
June 21	67	65·7	62
June 24	50	50·8	881
July 4	55	57·4	974
1941			
July 1	62	62·1	862
July 22	65	67·1	443
Aug. 4	67 (69)	66·9	85
Aug. 22	73 (74)	73·1	106
Sept. 8	76	76·1	195
Oct. 1	82	81·3	313
Oct. 20	85	82·0	104
Nov. 4	77	77·0	58
Dec. 4	92	92·9	255
1942			
June 9	53	55·6	743
Aug. 31	72	71·9	36

These investigators held that the l_1 values were a result of a prolonged spawning period, and it is known that in the Irish Sea there are spawning herrings from September to December. The presence of modal groupings in the l_1 values indicates that spawning is more concentrated at some parts of this period than at others. The 100 mm. mode represents a later optimum since the herrings with l_1 values of 130 mm. would already be about 30 mm. in length by the time the others were hatched. Considering these modal values the one at 100 mm. may be connected with a first year growth of 0-group herrings as illustrated in Figure 2 — that is, with later spawned fish — but the 130 mm. mode is not reflected at all in the length measurements of the fish dealt with in this paper.

The lower length values found in 0-group herring in 1941, as compared with 1939, are also covered by the first year growth of adult Manx herrings (l_1 values) the lower ranges of which are from 70 to 80 mm.

If these facts are taken in conjunction with the later spawning that occurs off the North Wales coast, then a primary case may be advanced that the 0-group herring caught in Penrhyn Weirs during 1939 and 1940 were of local origin and consequently were spawned November—December.

Summary.

1. The 0-group herrings were selected from whitebait samples caught in Penrhyn Weirs, Menai Straits, North Wales, during 1939 and 1940 and their length-frequencies examined until the laying down of the first "winter" ring in the scales. Further samples were received in 1940 to 1942.

2. Examination of earlier samples in 1939 showed that modal values represented at least three broods making up the 0-group. It is deduced that the hatching of these broods may be contained in a period of approximately six weeks.

3. A general increase in the length of herrings, as reflected in median and modal values, took place during the period June to November and this part of the growth curve requires little smoothing (Figure 2). From November to January the plottings of the medians and the principal modes are irregular and in themselves indicate a quickening growth at the end of November and further growth in December to January.

During this period, however, there is an influx of larger 0-group herring which have not been in evidence since the earliest samples. Consequently the length frequency distribution is widespread, the curves flatter in contour, and the position of the modes and medians less dependable.

At this same period guidance with regard to the amount of growth may be obtained from the herring scales. These first showed transparent edges in herrings of the 24th November sample and complete

rings were doubtfully present in a few fish by January. It is generally considered by investigators that there is minimum growth in the herring when a "winter" ring is being laid down (from November to May in the particular case). From this evidence there is little doubt that the curve in Figure 1 should be approaching the horizontal and this consideration has weighed in plotting the broken-line part of the curve Figure 2 from November onwards.

4. A comparison is made between the growth of 0-group herring from North Wales, and those obtained from the Plymouth area (Ford) and Clyde (Marshall, Nicholls, and Orr) as expressed by median values (Table II). In Welsh herrings the rate of monthly increment is lower throughout the growth period.

5. The origin of the whitebait herring. Adult herrings caught in the Menai Straits during November are about to spawn or have already spawned. There is similarity between the scale readings of these adult fish and herrings of the Isle of Man shoals which spawn earlier. The l_1 (first year) values of these latter are from 70 to 180 mm. with modal groupings about 100 mm. and 130 mm.

The 100 mm. mode may be connected with first year growth such as that illustrated in Figure 2 and since the lower values of the l_1 dispersion represent later spawned fish, it may be concluded that the 0-group herring dealt with are the product of the local late spawning in November and December.

I wish to acknowledge the practical assistance given to me by Mr. John Atkins.

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Review of the Scottish Lemon Sole Fishery at Faroe with Special Reference to the Years 1933 to 1938.

By

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According to the *Bulletin Statistique* the weight of lemon soles caught at Faroe decreased from 20 %, in 1932, to 12 %, in 1936, of the total weight of the species caught in the north-eastern Atlantic. Considering the comparatively small area of the fishing grounds at Faroe these figures at once indicate their importance as a source of lemon soles. Except for negligible quantities the complete catch of this species at Faroe is taken by British trawlers.

Since 1922 the annual British catch of lemon soles in this area has varied from 24 % to 11 % of the total landings of lemon soles in Great Britain from all areas. After reaching a maximum in the years 1931—32 the catch from Faroe has diminished steadily, although the landings from all areas have been fairly well maintained (see Table 1).

Table 1.

Total British Landings of Lemon Soles from Faroe in Cwt. with Percentages of the Totals from All Areas.

Year	1922	1923	1924	1925	1926	1927	1928	1929	1930
Cwt.	12,674	18,943	20,405	19,771	16,697	19,874	17,286	15,409	23,804
%	16	23	24	21	17	14	12	11	18
Year	1931	1932	1933	1934	1935	1936	1937	1938	
Cwt.	36,443	39,643	33,933	24,412	26,038	23,257	17,917	26,079	
%	24	22	21	15	15	14	11	17	

During the same period the annual Scottish share in the British catch from Faroe has fluctuated between 15 and 38 %, although since 1931 it has remained consistently at 30 % or over and the tendency is for it to increase.

Before dealing with the lemon sole fishery in detail it is of interest to note its position with regard to the other species caught by Scottish trawlers in the area. Of the total yearly weight of all kinds of fish landed from 1933 to 1938 cod show a fall from 61 to 41 % while haddock rise from 19 to 38 %, the variations in both cases being due partly to fluctuations in brood strengths and partly to the scarcity or abundance of these species on other fishing grounds. These two species thus form from 79 to 87 % of the total annual catch by trawl at Faroe. Of much less importance from the point of view of weight are saithe and lemon soles, each of which contribute from 3 to 6 % of the yearly total, while monkfish (*Lophius*), whiting, and halibut each make up 1 to 3 %. Lemon soles alone exceed the total weight of all other flatfish caught by the trawl, namely halibut, plaice, witch, megrim, dab, and turbot.

Table 2.

Scottish Landings from Faroe.

Year	Number of Trips	Average Length of Trip in Days	Number of Hours Trawling	Weight of Lemon Soles in Cwt.	Average Weight of Lemon Soles per 100 Hours Fishing
1933	811	11·4	64,312	10,841	16·9
1934	686	11·2	53,313	7,434	13·9
1935	683	11·8	58,931	7,818	13·2
1936	888	11·9	75,640	8,828	11·7
1937	650	12·5	54,783	5,999	10·9
1938	624	12·4	58,934	10,505	17·8

Although the lemon sole is greatly exceeded in weight by cod and haddock, its real importance is obvious when the price it fetches in the market is considered. For many years now it has commanded the highest price per cwt. in Scottish markets. In recent years its average price per cwt. has varied from 3½ to 5½ times as much as the corresponding price for haddock. In actual value, therefore, the lemon sole comes a close third in importance to cod and haddock.

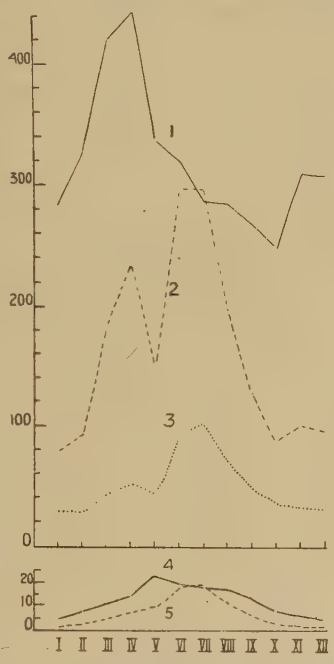
It has already been shown that the catch of lemon soles by British vessels at Faroe is declining. This of course is also noticeable in the Scottish landings and is partly explained by the fact that, since 1933, the number of trawlers visiting Faroese grounds has fallen, except for a temporary increase in 1936. At the same time the average length of the trips has increased by one complete day within six years. Accompanying the fall in the total landings of lemon soles to a minimum in 1937 is a decline in the average catch per 100 hours fishing. These facts indicate a growing scarcity of this species on Faroese fishing grounds. In 1938, however, despite a further reduction in the number of trips the landings of lemon soles and the average catch per 100

hours fishing show a remarkable improvement. In order to understand this it is necessary to study the monthly landings over the period and to consider some general aspects of the trawl fishery at Faroe.

On Faroese grounds trawling is mainly carried on during the night. For the greater part of the year the results of daylight trawling are so meagre as to render it often quite unprofitable. In March and April, trawling, almost entirely confined to the hours of darkness, yields the highest catches per 100 hours fishing for the whole year. With increasing daylight during the late spring the number of hours during which trawling can be prosecuted is further reduced so that in May a number of vessels is generally withdrawn from the Faroese grounds until it is more profitable to fish there. During May, however, in certain years, a partial daylight fishing is experienced, especially on Fuglø grounds when the quantities of lemon soles caught render fishing just profitable, this species alone being taken in any number in some localities. Short periods of daylight fishing are sometimes reported as early in the year as January, when fish of all kinds are taken, but these instances may be regarded as exceptional.

About the beginning of June a change occurs and daylight trawling becomes possible on all grounds, thus increasing the number of hours in which fishing may be carried on. Daylight fishing continues, with yearly variations, into August when trawling again becomes confined almost completely to the hours of darkness. The regular appearance of jellyfish on the Faroese grounds towards the end of the summer daylight fishery also contributes to make operations less profitable at this time. So heavy are the catches of these animals at times that the cod-ends are frequently burst or the fish in them ruined by the weight. Other factors which tend to hamper trawling at Faroe are strong winds, strong tidal streams, and fog.

These facts provide a clearer background for the understanding of the figures in Table 3 and of the diagrams.



Diagrams to illustrate Trawling at Faroe: Averages for 1933—1938 (see Table 3).

1. Average weight of *all kinds of fish* per 100 hours fishing in cwt.
2. Total weight of *all kinds of fish* in 100 cwt.
3. Total number of hours fishing in hundreds.
4. Average weight of Lemon Soles per 100 hours fishing in cwt.
5. Total weight of Lemon Soles in 100 cwt.

Table 3.

Average Monthly Landings of Scottish Trawlers from Faroe: 1933 to 1938

Month	Number of Trips	Total Hours Fishing	Total Weight: all Fish (cwt.)	Total Weight: Lemon Soles (cwt.)	Average Weight per 100 Hours all Fish (cwt.)	Av. Weight per 100 Hrs. Lemon Soles (cwt.)	Percentage of Lemon Sole in Total
Jan.	39	2,775	7,865	130	283	4·7	1·7
Feb.	38	2,851	9,258	225	325	7·9	2·4
Mar.	60	4,343	18,295	474	421	10·9	2·6
Apr.	75	5,241	23,287	735	444	14·0	3·2
May	60	4,479	15,154	1,002	338	22·4	6·6
June	103	9,274	29,675	1,791	320	19·3	6·0
July	106	10,281	29,553	1,823	287	17·7	6·2
Aug.	73	7,056	20,009	1,179	284	16·7	5·9
Sep.	52	4,802	12,843	623	267	13·0	4·9
Oct.	36	3,565	8,815	271	247	7·6	3·1
Nov.	40	3,221	9,990	177	310	5·5	1·8
Dec.	38	3,099	9,651	141	311	4·5	1·4

Thus the total weight of all kinds of fish landed follows in general the total number of hours trawling with two maxima in spring and summer, the latter being the more pronounced. The curve illustrating the average weight of all kinds of fish caught per 100 hours trawling, however, attains a maximum in March and April but decreases thereafter until October, after which an improvement is registered. Although not indicated on the average curve for 1933—1938, a second maximum of less importance is noticeable during the last two years, 1937—1938.

In the case of the lemon sole it is found that the greatest catch per 100 hours fishing occurs in May although there is little decline through-

Table 4.

Total Landings of Lemon Soles by Scottish Trawlers from Faroe with Average Catches per 100 Hours Fishing in Cwt.

Month	1933		1934		1935		1936		1937		1938	
	T.	Av.	T.	Av.	T.	Av.	T.	Av.	T.	Av.	T.	Av.
Jan.	151	7·7	165	6·1	172	5·8	108	4·5	76	2·1	109	3·5
Feb.	290	12·3	161	10·0	166	8·6	178	5·8	314	6·6	241	7·1
Mar.	758	16·2	355	10·3	366	9·5	457	8·6	291	7·0	618	13·4
Apr.	1401	19·3	530	10·7	384	11·4	541	9·8	366	8·5	1188	19·7
May	1405	24·8	966	20·6	1134	22·8	701	14·7	302	14·2	1500	32·0
June	1890	25·4	1810	27·1	1696	15·3	2457	14·8	864	15·5	2029	24·5
July	1872	20·0	1498	15·5	1574	15·9	2378	15·5	1508	21·9	2108	20·0
Aug.	1296	19·2	970	12·6	1206	17·6	1341	14·0	818	15·6	1443	23·2
Sep.	1038	15·0	503	11·9	660	11·9	327	8·2	507	12·2	703	17·6
Oct.	362	6·6	297	8·1	166	6·6	151	5·9	373	9·1	277	9·0
Nov.	153	5·6	90	4·5	184	5·4	107	2·8	348	7·2	181	7·0
Dec.	225	8·4	89	4·3	109	4·1	81	3·1	233	4·5	107	4·5

T. = Total, Av. = Average.

Table 5.

Totals and Percentages of Trade Categories in Scottish Landings from Faroe.

		1933	1934	1935	1936	1937	1938
Large:	Cwt.	2,095	1,476	1,517	1,656	958	1,421
	%	19	20	19	19	16	14
Medium:	Cwt.	3,059	2,045	2,221	2,240	1,325	2,144
	%	28	27	29	25	22	20
Small:	Cwt.	5,687	3,913	4,080	4,933	3,716	6,940
	%	53	53	52	55	62	66
Totals		10,841	7,434	7,818	8,829	5,999	10,505

out the summer until September. May to August is also the period of the heaviest landings of this species, particularly June and July. The main lemon sole fishery therefore coincides with the summer daylight fishery.

An explanation of the high lemon sole figures for 1938 compared with those of 1937 is obtained if these years are examined in detail. Although a larger number of trips is recorded in 1937 than in 1938, the number during the height of the summer fishery is less in 1937. The result is therefore smaller landings of lemon soles and a lower average catch per 100 hours fishing. In 1938, on the other hand, the number of trips is relatively high during the summer and low during the remainder of the year. This accounts to a large degree for the high landings of lemon soles and also for the high average catch per 100 hours fishing. It is also thought that the high figures for 1938 may, to a slight extent, be due to the introduction of a new system (abandoned in the following year) of weighing flatfishes in the Aberdeen market which resulted in greater accuracy than that hitherto achieved.

It is clear therefore that although the 1938 landings suggest a marked recovery in the downward trend of the fishery at Faroe, they are somewhat misleading, as they are due largely to the incidence of trawling in 1937 and 1938.

An examination of the trade categories of large, medium, and small lemon soles from 1933 to 1938 shows that during the first four years the percentages in each category remain practically constant. In 1937 a fall is registered in the large and medium sizes, which, of course, is accompanied by a rise in the percentage of small fish. This tendency is still more apparent in 1938 and it may be noted that the weights of large and medium fish landed are much below the corresponding

Table 6.

Monthly Percentages of the Total Weight of Lemon Soles landed by Scottish Trawlers from Faroe 1933 to 1938.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1·5	2·6	5·5	8·6	11·7	20·9	21·3	13·7	7·3	3·2	2·1	1·6

Ta

Grounds Fished by Scott

Month	Jan.		Feb.		Mar.		Apr.		May		Ju
No. of Trips with Grounds Known	34		35		63		79		66		1:
Grounds	No.	%	No.	%	No.	%	No.	%	No.	%	No
E. Suderø	2	6	—	—	—	—	1	1	—	—	—
SW. to NW. Suderø	5	15	10	29	6	10	2	3	—	—	14
W. Skuø	—	—	1	3	4	6	8	10	1	2	8
W. to S. Myggenaes	4	12	13	37	10	16	20	25	4	6	11
W. to NE. Myggenaes	3	9	10	29	3	5	2	3	4	6	33
SW. to NE. Myling Hd.	12	35	15	43	10	16	8	10	8	12	28
NW. to NE. Kadlur	18	53	13	37	14	22	41	52	22	33	18
NW. to NE. Enniberg	5	15	7	20	10	16	15	19	8	12	8
NW. to E. Fuglø	4	12	15	43	32	51	19	24	31	47	99
E. to S. Fuglø	11	32	13	37	20	32	18	23	30	45	85
E. to S. Bordø	3	9	—	—	4	6	6	8	1	2	2
E. to S. Nolsø	4	12	3	9	5	8	11	14	7	11	29
E. Sandø	1	3	—	—	1	2	—	—	1	2	2
All round Faroe	2	6	—	—	—	—	2	3	—	—	—
Fuglø Bank	—	—	—	—	2	3	3	4	1	2	—
Nolsø Bank	—	—	—	—	1	2	1	1	—	—	—
Sandø Bank	—	—	—	—	1	2	1	1	—	—	2
Faroe Bank	—	—	—	—	—	—	—	—	1	2	—

The first column under each month gives the number of trawlers fishing the grounds nam

Grou

figures for 1933, when an almost similar total weight of all sizes was landed. This indicates a growing scarcity of larger fish and greater dependence on the small sizes for market supplies. From the evidence of scales collected at Faroe in 1938 it would appear that the stocks of small fish were mainly dependent on the 1934 brood, which was giving promise of being of good but not exceptional strength.

In Table 6 are given the monthly percentages of the total weight of lemon soles landed from Faroe during the period 1933 to 1938. Of the total, 67·6 % was caught from May to August inclusive. Assuming the amount of lemon soles landed in each half of February to be the same, then 1·3 % may be regarded as having been landed after 15th February. Similarly 5·8 % may be regarded as having been landed before 15th May, although this may be slightly too high in view of the general incidence of the lemon sole fishery. Between 15th February and 15th May, therefore, about 21 % of the total landings of lemon soles from Faroe may be expected.

From information supplied by trawler skippers it has been possible to study the fishing grounds frequented by the Scottish fleet at Faroe for a complete year — 1936. Most vessels work on a number of grounds during each trip for various reasons such as weather conditions, presence of jellyfish, scarcity of fish, or the desire to obtain a more

awlers at Faroe, 1936.

July 157		Aug. 96		Sep. 58		Oct. 39		Nov. 55		Dec. 38		Month No. of Trips with Grounds Known
o.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Grounds
1	1	—	—	—	—	—	—	—	—	—	—	E. Suderø
2	20	14	15	3	5	4	10	3	5	1	3	SW. to NW. Suderø
5	3	11	11	3	5	—	—	1	2	—	—	W. Skuø
7	4	8	8	22	38	1	3	4	7	2	5	W. to S. Myggenaes
5	35	39	41	23	40	21	54	31	56	23	61	W. to NE. Myggenaes
3	24	12	13	15	26	2	5	3	5	5	13	SW. to NE. Myling Hd.
5	3	3	3	3	5	5	13	18	33	16	42	NW. to NE. Kadlur
3	5	3	3	—	—	2	5	4	7	—	—	NW. to NE. Enniberg
4	34	20	21	3	5	8	21	7	13	3	8	NW. to E. Fuglø
5	17	29	30	12	21	17	44	18	33	8	21	E. to S. Fuglø
5	4	11	11	2	3	4	10	5	9	8	21	E. to S. Bordø
5	10	15	15	10	17	6	15	6	11	4	11	E. to S. Nolsø
5	4	8	8	2	3	6	15	1	2	—	—	E. Sandø
0	6	5	5	9	16	3	8	5	9	—	—	All round Faroe
1	1	1	1	4	7	—	—	—	—	—	—	Fuglø Bank
2	1	2	2	2	3	—	—	—	—	—	—	Nolsø Bank
1	1	1	1	1	2	—	—	1	2	—	—	Sandø Bank
2	1	—	—	2	3	—	—	—	—	—	—	Faroe Bank

second column expresses this number as a percentage of the Number of Trips with own.

varied and balanced catch for the market. Most of the skippers work on bearings from certain prominent landmarks. The positions range from 4 to 15 miles from the islands but some vessels extend operations beyond this. The number of trawlers fishing each ground and their percentages of the total number of trips for each month, the grounds of which were ascertained, are given in Table 7. Obviously there is some overlapping of positions but, in general, reliable information is gained regarding the grounds most frequented from month to month.

A less detailed study of the fishing grounds for other years shows that 1936 is fairly typical. The grounds most favoured by Scottish trawlers are northerly, from Myggenaes eastwards to Fuglø and Nolsø. Those off Myggenaes are most heavily fished from July to February. The neighbouring Myling Head grounds are worked at the same time but particularly from December to February. Northern grounds off Kadlur receive most attention from November to May and those off Enniberg, though less frequented, from January to April. The grounds in the neighbourhood of Fuglø and east of Nolsø, which are more regularly fished throughout the year than those of any other region, receive special attention from February to August.

No information is available regarding the exact location of the catches of lemon soles but from the work of research vessels it is clear

that they are caught on all grounds. An age analysis of the Faroese stocks has shown that young fish up to 4 + years of age predominate on the northern grounds so that a large part of the catches of lemon soles from this area must consist of small fish.' From the reports of fishery officers, however, it would appear that during the first half of the year at least, the best catches of this species are procured on the Fuglø and Nolsø grounds.

In conclusion, during the period February to May, Scottish trawlers at Faroe concentrate most heavily on northern grounds where cod and haddock form the bulk of the catches, and on north-eastern grounds where a good proportion of lemon soles is obtained towards the end of this period.

Le *Lernaeocera branchialis* (L.), Copépode Parasite des Gadides.

Par

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Introduction.

NOUS avons pu, dès 1936 et jusqu'en 1940, grâce aux moyens de travail du laboratoire maritime d'Ostende, entamer une série continue de recherches sur différents Copépodes parasites et principalement sur le *Lernaeocera branchialis* (L.), remarquable parasite des Gadides.

Les principaux résultats de nos investigations anatomiques, histologiques et éthologiques, feront l'objet d'un mémoire qui sera prochainement publié *in extenso*.

Cependant, il nous a paru opportun de présenter dès maintenant aux lecteurs du Journal du Conseil International, un exposé très succinct de l'état actuel des connaissances sur ce parasite bien connu des pêcheurs, en indiquant les principaux points sur lesquels nous apportons quelques additions ou corrections aux observations faites par de nombreux prédécesseurs.

Sans doute nous n'en sommes pas à devoir lutter contre les Copépodes parasites des organismes marins. Mais il existe certaines lois générales qui s'appliquent aussi bien aux parasites du milieu marin qu'à ceux des eaux douces et les problèmes se touchent. Déjà la question du parasitisme des poissons d'eau douce par des Copépodes se pose en plusieurs pays et les zoologistes ont été amenés à lutter contre certains d'entre eux. Les *Lernaea* et *Ergasilus* se multiplient, dans des conditions favorables, au point de provoquer non seulement un affaiblissement de leur hôte, mais même de causer la mort d'un grand nombre d'individus.

I. Historique et dénomination du genre.

En 1767, Linné donne la première description du parasite. Après lui de nombreux auteurs complètent cette description parmi eux: O. Fabricius, O. F. Muller, J. Gmelin. Plus tard, de célèbres zoologistes tels que J. B. Lamarck, H. Blainville, G. Cuvier, H. Milne Edwards, se préoccupent surtout de la position systématique du parasite. Linné, en effet, l'avait classé parmi les "Vermes". Lamarck le considère d'abord comme un Mollusque céphalé ensuite comme un Annélide, enfin comme un Epizoaire, classe intermédiaire entre les Vers et les Insectes. L. Oken, bien que le considérant comme un Mollusque, le rapproche cependant des Caligides. Cuvier classe les véritables Lernéens parmi les Vers intestinaux cavitaires. Blainville enfin, en 1822, classe le *Lernaeocera* parmi les Crustacés. On avait observé que ses oeufs se développent en larves nauplius typiques.

Le nom du genre a également subi des changements, on trouve alternativement employé *Lernaea* et *Lernaeocera branchialis*. C. B. Wilson (1917) a résolu ce problème de nomenclature en maintenant le nom de *Lernaeocera* employé la première fois par Blainville en 1822; le genre *Lernaea* ayant été employé pour *Lernaea Cyprinacea*, espèce décrite par Linné avant *Lernaea branchialis* et n'appartenant pas au même genre.

L'étude anatomique du parasite a été faite par A. Nordmann (1832), H. Krøyer (1837), P. J. Van Beneden (1851), C. Claus (1867—1868), A. Scott (1901, 1912), C. B. Wilson (1917).

Le développement et certains problèmes physiologiques furent étudiés par E. Hesse (1863, 1870, 1891) et tout récemment par N. Sproston et P. Hartley (1941, 1942).

D. Pedaschenko (1898) étudie le développement embryonnaire et M. Gouillart (1937) a fait l'étude de l'ovogénèse et de la spermatogénèse comparée.

Dans ces dernières années enfin plusieurs recherches physiologiques sur le sang et la circulation ont été faites par L. Vanden Berghe (1933), J. H. Schuurmans Stekhoven et A. Punt (1936—1937), N. Panikkar et N. Sproston (1941).

II. Esquisse anatomique de la femelle adulte et de la larve.

A. La femelle adulte.

La femelle adulte (Fig. 1A) peut atteindre 4 à 5 cm. de long; vivante elle est rouge carmin foncé, couleur due au liquide sanguin à hémoglobine du parasite, vu par transparence à travers la paroi chitineuse.

Nous distinguons, avec Hesse et d'autres, trois régions principales; la tête, le cou, le corps. Ces appellations évidemment symboliques simplifient la description.

La tête (Fig. 1B) se termine en avant par un court cône buccal, à l'extrémité duquel s'ouvre la bouche. Ce cône porte latéralement et inférieurement les seuls appendices fonctionnels qui sont les maxilles I et II. Dans un même plan, mais dans trois directions opposées, nous voyons les trois "cornes" servant à la fixation du parasite.

Le cou (Fig. 1A, c) long tube chitineux, droit ou légèrement courbé, est presque toujours tordu sur lui-même.

Le corps (Fig. 1A, Cp), partie dilatée et coudée en S, a sa paroi chitineuse plus mince; elle contient les principaux organes. Ventralement, sous la grande courbure nous voyons les deux ovisacs (Fig. 1A, o). Ce sont deux longs tubes cylindriques; ils contiennent les oeufs, disques plats, disposés en pile de monnaie.

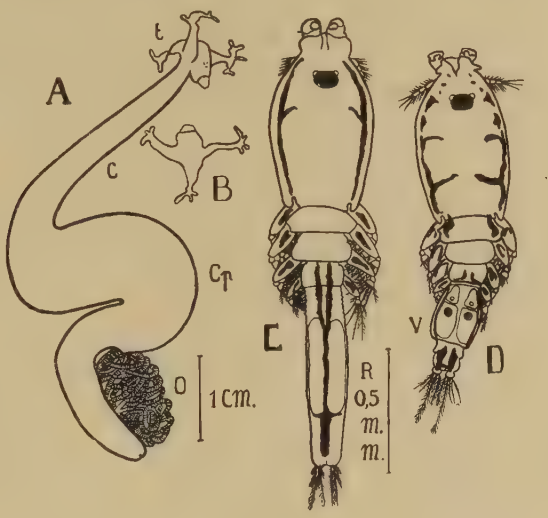

Fig. 1.
Lernaeocera branchialis (L.).
A. Femelle adulte vue de coté. — t, Tête. — c, Cou. — Cp, Corps. — O, Ovisacs.
B. Femelle adulte, tête vue de dessus.
C. Larve copépodite II femelle, R réceptacle séminal.
D. Larve copépodite II mâle adulte, V vésicule séminale.

B. La larve.

La larve (Fig. 1C et 1D) a presque l'aspect d'un copépode libre. Son corps se compose de quatre parties; 1° le céphalothorax résultant de la fusion de la tête avec le premier segment thoracique, 2° les trois segments thoraciques libres, 3° le segment génital, 4° l'abdomen résultant de la fusion des segments abdominaux.

La larve femelle atteint 2 mm. de long; le mâle reste plus petit. L'animal est presque transparent. Les seules modifications qui distinguent la larve à ce stade du copépode libre sont la bouche du type suceur, les antennes II modifiées en pinces, et la glande frontale secrétant la matière grâce à laquelle la larve se fixe à son hôte.

C. Origine des régions de la femelle adulte et les modifications des appendices.

La modification la plus importante est la perte chez la femelle adulte de toute segmentation; la paroi de l'animal est un tube de chitine continu et rigide.

La tête et le cône buccal proviennent de la transformation de la partie céphalique de la larve. Les trois cornes sont produites également par la région céphalique.

Le cou résulte de la transformation de la partie postérieure du céphalothorax (le premier segment thoracique soudé), des trois segments thoraciques libres et peut être du 5e segment (en partie).

Le corps provient du très grand développement du segment génital de la larve; la région postérieure aux orifices génitaux provient en grande partie de l'abdomen. L'anus est terminal comme chez la larve.

Peu d'appendices disparaissent mais la plupart sont très fortement régressés. Les antennes I et II sont visibles sur la tête mais leur forme est altérée. L'oeil nauplial est enfoncé dans les tissus et ne se retrouve que dans les coupes microscopiques. Les mandibules et maxilles I et II sont restées inchangées et fonctionnelles. Les pattes, au nombre de quatre paires, se retrouvent ventralement dans la région supérieure du cou, leurs segments sont soudés et peu distincts. Les lames anales, enfin, ne sont plus visible chez les exemplaires âgés.

D. Anatomie interne de la femelle adulte.

Le système nerveux central est réduit à un anneau periœsophagien.

Le système digestif a subi un allongement parallèle à celui de tout le corps. Il porte un épithelium à cellules en massues qui évoluent parallèlement à l'avancement de la digestion. Il n'existe pas de glandes annexes.

Il existe de nombreuses glandes excrétrices à structure syncytiale, réparties dans différentes régions du corps et débouchant directement à l'extérieur sans canal excréteur différentié. Les glandes maxillaires sont fonctionnelles.

Le système circulatoire consiste en deux lacunes principales, l'une dorsale, l'autre ventrale. Le sang contient de l'hémoglobine en solution et est mis en mouvement dans la lacune dorsale par le péristaltique du tube digestif. Le sens de la circulation varie alternativement après un temps et un nombre de contractions relativement constant.

La respiration a été etudiée par N. Sproston et P. Hartley (1941). Le parasite utiliserait uniquement l'oxygène contenu dans le sang du poisson ingéré et contenu dans le tube digestif.

Le système génital du mâle est presque identique à celui des copépodes libres. Celui de la femelle, au contraire, est fortement modifié et présente un grand intérêt. Voyons-en les principales caractéristiques.

Chez la larve, l'ovaire et l'ébauche de la glande cémentaire se trouvent situés dans le céphalothorax.

Chez la femelle adulte (stade VII) nous trouvons l'ovaire situé dorsalement au dessus des orifices génitaux, dans la petite courbure du corps, soit dans la région correspondante au segment génital de la larve. L'extrémité antérieure de la glande cémentaire se trouve à la base du cou, soit également bien en arrière du 4me segment thoracique transformé. On voit donc l'importance des déplacements subis par les

organes génitaux. M. Gouillart (1937) avait déjà attiré l'attention sur ce fait.

Le réceptacle séminal (Fig. 1 C_R) est composé de deux cavités parallèles et indépendantes chez la larve. Chez l'adulte il est transformé en une poche unique en forme de bissac. Sa position relative a été conservée.

La femelle est fécondée à la fin du stade VII, le mâle disparaît et meurt; il ne vit pas en parasite sur la femelle adulte, comme c'est le cas pour de nombreux autres genres de copépodes parasites.

Enfin, grâce au matériel récolté à différentes saisons et pendant plusieurs années, il a été possible d'étudier en détail l'ovogénèse si caractéristique, étudiée déjà par M. Gouillart (1937) qui n'a cependant pas observé les stades de multiplication des ovogonies. Il décrit de plus une multiplication amitotique des ovocytes, qui n'existe pas chez le *Lernaeocera*. Le système génital passant par une période de repos on y observe des stades déroutants et qui ne représentent pas l'ovogénèse normale du parasite.

Dans le noyau de l'ovocyte il a été observé une inclusion énigmatique, non cristalline, qui n'a pas été signalée jusqu'à présent.

III. Cycle du développement.

Les oeufs donnent naissance aux larves nauplius qui s'échappent et mènent une vie planctonique de 24 heures, puis se transforment en larves copépodides qui deviennent parasites sur les filaments branchiaux de l'hôte intermédiaire, un *Pleuronectes*, et y restent de deux à trois mois. A la fin du stade chalimus, soit aprés VI stades[1]), a lieu la fécondation. Le mâle adulte se détache de son hôte et meurt, tandis que la femelle, fécondée mais non adulte, va se fixer, après une courte vie planctonique, sur son hôte définitif, un Gadide. Elle s'enfonce dans les tissus; le corps se courbe, s'allonge, augmente de volume, la femelle acquiert bientôt son aspect typique en même temps que sa maturité et elle commence à pondre.

Elle vit plusieurs années. On trouve en effet sur les gadides âgés, des exemplaires de très grande taille qui continuent à pondre.

IV. Mode de fixation du parasite.

La larve chalimus vit fixée près de l'extrémité des filaments branchiaux du *Pleuronectes*. On l'y trouve parfois par centaines, surtout au printemps et en été.

La larve est fixée au filament par une substance spéciale sécretée par une glande appelée glande frontale; cette substance souple mais résistante est littéralement injectée dans les tissus du filament où elle

[1]) N. Sproston (1942) distingue un stade nauplius, un stade copépodide libre, quatre stades chalimus.

prend la forme d'une massue irrégulière portant de nombreuses expansions. Divers Copépodes parasites se fixent ainsi à leur hôte par des sécrétions spéciales de glandes frontales ou autres et souvent même les "boutons" de fixation possèdent une forme régulière et caractéristique pour l'espèce.

Ainsi fixée par son extrémité antérieure, la larve se maintient contre le filament à l'aide de ses maxilles et, y appliquant sa bouche, ronge les tissus et avale le sang et le mucus de son support.

Le mode de fixation de la femelle adulte est fort différent. On la trouve toujours dans la chambre branchiale de son hôte, partiellement mais profondement enfoncée dans les tissus. Elle se fixe soit sur l'arc branchial soit dans la région cardiaque et seul le corps et les ovisacs sont visibles *in situ*. La bouche plonge soit dans le coeur, soit dans un des gros vaisseaux d'où le parasite suce le sang qui le nourrit.

V. Les hôtes et la répartition géographique.

Les larves copépodides, qui vivent sur les *Pleuronectes flesus* et *platessa*, ont été trouvées sur les côtes européennes de l'Atlantique, depuis la France jusqu'à la Norvège. Il est vraisemblable qu'elles vivent cependant sur une aire plus étendue. Les hôtes habituels de la femelle adulte sont *Gadus callarias* L., *G. aeglefinus* L., *G. merlangus* L., *G. luscus* L.; exceptionnellement on l'a trouvée sur *Molva molva* L., *Morone labrax* L., *Solca vulgaris* et d'autres.

L'aire de dispersion géographique du *Lernaeocera branchialis* adulte correspond évidemment à celle de ses hôtes, c'est-à-dire aux eaux froides de l'Atlantique Nord, depuis la Mer du Nord à l'Est jusqu'à la côte Américaine à l'Ouest. J. H. Schuurmans Stekhoven (1936) a mis en doute l'identité de l'espèce signalée sur la côte américaine, avec l'espèce typique; mais à notre connaissance on n'a pas encore signalé de larves copépodides sur la côte Américaine. Il n'y a donc pas lieu de mettre en doute la détermination de C. B. Wilson Seule la présence sur cette côte d'une larve copépodide différente de celle du *L. branchialis* et dont on aurait suivi le développement ultérieur, pourrait justifier la création d'une nouvelle espèce.

Il existe peut-être sur les Gadides des eaux froides de l'Atlantique Sud, un *Lernaeocera* identique ou voisin de celui que nous connaissons dans le Nord. Cobbolt (1885) décrit un *Lernaeocera* récolté par Ch. Darwin. Cunningham (1871) en décrit et en représente un autre, mais ces descriptions sont trop peu précises et depuis cette époque aucune capture n'a été signalée.

VI. Pourcentage des poissons parasités et effets du parasite sur ses hôtes.

Dans une même région et pour des hôtes de même espèce et de même âge, le pourcentage de poissons parasités varie fortement d'une

année à l'autre. A. Scott (1929) écrit:— "Although widely distributed, the occurrence of the adult female on gadoid hosts is generally spasmodic. One may examine many fish without finding *Lernaeocera*. At other times, nearly every small whiting in a catch will have at least one *Lernaeocera* ..... Between 80 and 90 per cent. of these young whitings (12—24 cm. in length) at times had at least one *Lernaeocera*. Some had two, some three and one no less than seven *Lernaeocera*."

J. H. Schuurmans Stekhoven (1936) signale que 14 % de *Gadus callarias* pêchés au Helder, sont parasités. Dans la région d'Ostende nous avons observé des pourcentages variant entre 10 et 60 %[2]).

Il en va autrement pour les larves et les hôtes intermédiaires. En effet, il est rare de pêcher au printemps sur la côte belge, un *Pleuronectes flesus* qui ne soit pas parasité par quelques dizaines ou centaines de larves.

Malgré leur grand nombre, les larves ne paraissent pas causer d'importants dégâts à leur hôte; les *Pleuronectes* sont en effet des poissons très résistants et nous avons vu que le parasitisme de la larve ne dure qu'un temps limité.

Pour les Gadides parasités par la femelle adulte, il nous faut distinguer entre les jeunes individus (moins de 4 ans) et les individus âgés.

Chez les individus âgés il est rare de voir une différence entre un poisson parasité et un autre qui ne l'est pas. Chez les jeunes, par contre, les conséquences du parasitisme sont souvent telles, que l'on peut reconnaître les poissons parasités d'après leur aspect extérieur. Ils sont émaciés et même comme le dit T. Scott (1909) "reduced almost to skin and bone". Certains individus, bien que parasités, semblent cependant être indemnes. N. Sproston et P. Hartley (1941) constatent également un affaiblissement marqué du poisson parasité.

L'effet du parasite sur son hôte dépendrait de trois facteurs variables: le nombre de parasites, la situation du parasite dans l'hôte, et la réaction de l'hôte au parasitisme.

Le nombre de parasites peut atteindre sept, mais les cas les plus fréquents sont un et deux parasites.

La situation occupée par le ou les parasites n'est pas toujours la même. On comprend qu'un parasite fixé dans l'arc branchial et dont la bouche plonge dans une artère branchiale, cause moins de dommages à son hôte, qu'un autre dont la tête plonge dans le coeur ou tout près de cet organe.

Enfin, tous les hôtes ne réagissent pas de la même façon au parasitisme. Chez certains la région entourant l'endroit de pénétration du parasite est saine et bien cicatrisée; chez d'autres, au contraire, la plaie suppure et est envahie par d'autres organismes.

[2]) N. Sproston et P. Hartley (1941) ont étudié le pourcentage du parasitisme dans la région de Plymouth et les variations de ce pourcentage en relation avec les migrations des hôtes.

Lorsque le parasite meurt, la tête et le cou restent enfoncés dans les tissus et si certaines causes d'affaiblissement peuvent disparaître, d'autres restent, et il est certain que la présence de la tête dans la région cardiaque peut causer encore de sérieux dommages à l'hôte, surtout par infection bactérienne.

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Note.

Establishment of a Division of Oceanography in the United States Navy Hydrographic Office.

THE Hydrographic Office has just established a Division of Oceanography to provide for increased responsibilities in oceanography recently assigned to the office by the Secretary of the Navy.

Because of experience during the war, the Navy considers that a considerable expansion of our knowledge of the oceans is necessary to guide the development of new naval equipment and to aid in strategic and tactical planning. Such an improvement in our understanding of the oceans will require a great increase in fundamental oceanographic research. This is true because our present basic oceanographic knowledge has been extended to the limit in its practical application during the war. In addition, new oceanographic techniques have opened many new possibilities of further fundamental investigations.

It is believed that such basic oceanographic research should be of value not only to the Navy, but also to many other governmental activities interested in the oceans, their land and air borders, and the organisms living in the sea, as well as to scientific institutions and to various commercial interests. For example, the increase in air travel over water has given increased emphasis to problems of maritime meteorology and air-sea rescue, requiring a knowledge of ocean currents. The extension of United States responsibility to regions of the western Pacific has greatly added to the national interest in geophysical and other problems of those areas, of which oceanographic problems are an integral part. Development of new fisheries and conservation of existing fisheries resources may in the future depend more and more on better oceanographic knowledge.

By expanding its oceanographic work, the Hydrographic Office will be continuing its tradition of service to the mariner and will afford other agencies a facility for coordination of oceanographic observations and research. The Hydrographer intends to maintain a central oceanographic library, central files of oceanographic data (to be published in a special bulletin), and a bibliographic service and to

provide charts and manuals utilizing the results of the most recent research. In carrying out this work, the Hydrographic Office will not only make use of the services of its own personnel in the newly established Division of Oceanography, but also will give financial support to oceanographic institutions to permit them to expand their facilities for basic research of interest to the Navy and other governmental agencies. In addition to publications of immediate practical use to mariners, the Hydrographer proposes to publish a series of technical studies which will be of interest to those working in applied oceanography as well as to personnel at research institutions not only in the United States but also abroad.

To insure an organization most useful to the government and the maritime interests of the nation, an Advisory Committee consisting of representatives of interested activities in the Navy and other government agencies is being formed to advise the Hydrographer concerning oceanographic problems of special interest to the agencies represented to assist in coordinating governmental research in oceanography, and to give continuing endorsement to the programme. Cooperation of this sort should prove to be a most economical means of furthering the oceanographic interests of the country.

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Rear Admiral, U.S.N.
Hydrographer.

Reviews.

Note. The reviews published below were all received after the last number of the Journal had been published, in December 1939. It is regretted that there has been no earlier opportunity to publish them.

Editor.

W. R. G. Atkins and **H. H. Poole.** "A cubical photometer for studying the angular distribution of submarine daylight." Journ. Mar. Biol. Assoc., Vol. XXIV, No. 1, 1940, pp. 271—281. Cambridge 1940.

The paper, by the two acknowledged masters of submarine-light research, is a valuable contribution to our knowledge of subsurface illumination, hitherto mostly studied by means of plane receptors exposed to light from above. As the title of the paper indicates, a special photometer case was constructed with six rectifying cells exposed behind opal glass and a green filter to light falling on the six sides of the cube, two of which were kept horizontal and four vertical by means of the suspension, and further stabilized by a current-vane, so as to minimize rotation round a vertical axis. The photo-electric currents generated could be read on a Tinsley light-spot galvanometer of improved construction, united with the photometer cells by means of a 7-stranded cable. In rough weather with a heavy swell the potentiometer-telephone equipment developed by the authors was used instead. Measurements made both in the open sea of the English Channel and inside the Plymouth breakwater indicate that the ratio between illumination from below and from above varied between a minimum of 1·8 % in very clear water and a maximum in comparatively turbid water of 8·5 %. The ratio between total horizontal light and light from above was found to vary from 64 % to 90 %. The corresponding "mean obliquity of daylight" (apart from direct sunlight) works out at nearly 40° from the vertical and was *not* found to increase with increased depth, an effect found by Johnsson and Liljestrand in Swedish fjords by means of a different technique. A decrease in the latter measurements in the amount of scattering particles with depth, which is quite common in Swedish coastal waters, or possibly, a slight increase in the tilt of the cubical photometer with depth due to currents in the English measurements may well explain this apparent discrepancy in the results. Continued measurements by the cubical photometer under varied conditions of locality, depth and incident daylight appear highly desirable.

Hans Pettersson.

G. A. Riley. "Correlations in Aquatic Ecology. With an Example of their Application to Problems of Plankton Productivity." Journ. Mar. Research, Vol. 2, No. 1, pp. 56—73. New Haven, Conn., 1939.

In this paper Riley uses a variety of data from physico-chemical and plankton studies in Linsley Pond primarily to illustrate the applicability of selected statistical methods to œcological problems. It is, in essence, "a study of the relation between statistical and biological significance" and, as such, will be welcomed by those who wish to apply a more rigorous test to their data than is provided by mere inspection. Further, by the use of partial correlations and non-linear regressions a closer approach to true biological significance is obtained than by simple correlations. Riley stresses the point that the type of data available to the œcologist is rarely free from large experimental and other errors and reminds us that a correlation neither propounds nor proves a theory. "The correlation is merely a fact, to be weighed in relation to other facts."

This warning cannot be too often repeated, for it is sometimes in danger of being overlooked and mathematical treatment of biological data regarded as the supreme criterion, whereas, in fact, there must be many instances when statistical examination can only lend apparent support to an hypothesis, which improved technique will show to be untenable. It is with this point in mind that the following has been written.

Estimates of production of plankton are necessarily based on methods which may be precise, by which is meant that replicate observations agree closely, but for all that, the method may fail to supply the data required. The classical researches of Lohmann and of Allen, for instance, showed that there are in the sea a host of very small organisms, the numbers of which were grossly underestimated by existing methods. Utermöhl (Arch. f. Hydrobiol., *18*, 1927, p. 464) showed that his sedimentation technique provided a truer estimate of the total plankton content than did the centrifuge, but it is still not known with certainty how nearly Utermöhl's estimate approached the true value. Riley has based *one* estimate of production on the amounts of chlorophyll extracted. Harvey (Journ. Mar. Biol. Assoc., 19, 1933, p. 761) showed that pigment extracts by his method were in good agreement with the numbers of individuals in the plankton, allowance being made for difference in size. But Harvey's material was net-caught plankton, from which the small forms would be partially absent. In freshwater, however, I am aware of no published data which provide a similar comparison of numbers of individuals with pigment extracts, and until these are available too much reliance should not necessarily be placed upon the method. Indeed, the ratios of phytyl chlorophyllide to organic content in seston, computed from Kozminski's data (Trans. Wis. Acad. Sci., *31*, 1938, p. 431 *et seq.*) prompt the question whether we are not to-day in danger of relying too much upon chemical methods and paying too little attention to the living plants and animals themselves.

My reason for this statement is that for some time, I have endeavoured to make use of a modification of Harvey's technique in freshwater. One shortcoming of the method is the failure of acetone to decolorize algae belonging to classes other than the Diatomaceae. If, for instance, a mixed plankton which has been treated with 80 or 100 % acetone for 20 hours be examined under the microscope, it will be found that whilst the diatoms are apparently devoid of pigment, such genera as *Scenedesmus, Ankistro-*

desmus, Pediastrum, Eudorina, and smaller unicellular Volvocales are still far from completely decolorized, as also are *Anabaena, Aphanizomenon, Microcystis, Oscillatoria,* the Dinoflagellate *Ceratium,* and the "Yellow-green" *Tribonema.* Members of the Chlorophyceae will still be a vivid green, whilst the species of Cyanophyceae have lost much yellow and some red pigment, as measured with the Lovibond Tintometer, leaving the cells a faint blue-green. This objection, it is true, may not apply when one pigment only, chlorophyll, is estimated as Riley recommends in an earlier paper (Int. Rev. 36, 1938, p. 371). But it is difficult to see why Chlorophyceae should appear *green* after extraction with acetone, whilst diatom cells are colourless, in view of the findings of Carter, Heilbron, and Lythgoe (Proc. Roy. Soc. B., *128*, 1939, p. 102) that a difference between Chlorophyceae and Diatomaceae is the presence of an *additional* pigment, fucoxanthin, in the latter. If, then, the separation of chlorophyll be attempted from an initial extraction for three hours with acetone (Riley, 1938, p. 371) it may result in underestimating the total content of "green pigment". The use of the words green pigment is here deliberate, because I do not know the function of this residual pigment in Chlorophyceae. If it be that much of it turns out to be chlorophylls then, clearly, estimates based on the amounts of these substances separated from an initial 3-hours treatment with acetone will be too low. One would also be forced to enquire why Chlorophyceae need an amount of photosynthetic catalyst so much in excess of that in diatoms. If it merely serves the same purpose as the accessory pigments, xanthophyll, carotene, etc., and is not chlorophyll — and so will not saponify with alcoholic potash — then estimates based on chlorophyll may prove to be the only way in which this method of measuring plankton concentration should be attempted.

Estimates based on pigment extraction have so much to recommend them that it seems essential to enquire more closely into its reliability before it becomes a generally accepted method. Other solvents may be found which will bring about more complete extraction, and of a number which I have tried the best seems to be methyl alcohol. Carter, Heilbron, and Lythgoe, using larger amounts of algae than would be the case in plankton extractions, carried out an initial extraction for 2 to 3 days with methyl alcohol, followed by warming for a few hours, under reflux, with a mixture of equal parts of acetone and ether. Kozminski has apparently found it necessary to grind the plankton in acetone and states (loc. cit., p. 414) that "complete extraction is not easy in some cases and requires large amounts of acetone. It would probably be better to grind the residue with the addition of some diatomaceous earth." Emerson (Journ. Gen. Physiol., *12*, 1929, p. 617) who measured the concentration of chlorophyll per unit cell volume of *Chlorella,* extracted the mixed pigments with methyl alcohol.

Neither the findings of others, nor my own observations, provide sufficient grounds upon which to base a criticism of Riley's modification of Harvey's method. Even less do they detract from the value of Riley's use of these data to illustrate a statistical method. They do entitle me, however, to draw attention to the difficulties which may be encountered in freshwater. The solution of these difficulties, moreover, may serve to remove some of the anomalies which have come to light in attempts to correlate productivity with physico-chemical factors of the environment.

A. C. Gardiner. (†).

H. Pettersson, F. Gross and **F. Koczy.** "Large-Scale Plankton Cultures." Med. från Oceanogr. Inst. i Göteborg. 3. Göteborgs Kungl. Vet.- och Vitt.-Samf. Handl., 5 Föl., Ser. 13, Bd. 6, No. 13. Göteborg, 1939.

A tank has been built at the Oceanographic Institute in Göteborg, 12 metres deep and 2 metres in diameter, to hold sea water which can be kept at nearly constant temperature by means of cooling coils. The purpose of this plankton shaft is to represent as nearly as possible an immobilized water column representative of the water in the Swedish fjords, as exists for instance during the spring increase of diatoms, and to provide facilities for changing one or other of the physical and chemical conditions affecting their growth. The shaft is lit from above by a battery of mercury and sodium vapour lamps; it is provided with observation windows and is filled slowly from the bottom — an arrangement by which layering of water of different salinities or temperatures can be obtained.

In the preliminary experiments described in this report the shaft was filled with sea water which had been previously sterilized by exposure to ultra-violet light. The upper part of the shaft was filled with water of 28 ‰ salinity and maintained at 7 to 9°C. while below it was water of 35 ‰ salinity at 14°C. The discontinuity layer remained sharp and distinct.

When mixed diatom plankton was introduced into the upper layer and lights turned on for 8 to 10 hours daily there was growth of autotrophic flagellates and of diatoms, some species of the latter increasing more rapidly than others. *Skeletonema* cells in 21 days increased to 80 times the number added, *Rhizosolenia alata* more than doubled, while the *Thalassiothrix* population declined.

In the first experiment when zooplankton, mostly copepods, were added, the population appeared to be maintained for some fifteen days, after which it declined, although diatoms and flagellates were added as food. In a second similar experiment the zooplankton died out more rapidly; the temperature was higher than in the previous experiment, 14°C. compared with 10°C., and this difference was considered a cause of the shorter survival. In these experiments the photostatic response of the copepods was very marked.

H. W. H.

G. A. Riley. "Plankton Studies II. The Western North Atlantic, May—June 1939." Journ. Mar. Research, Vol. 2, No. 2, pp. 145—162. New Haven, Conn., 1939.

Observations were made at a series of deep water stations from 23°N. to 40°N. in the Atlantic between Cuba and Woods Hole. The aim of the investigation was to estimate the total standing crop or momentary population of phytoplankton at each position, to seek for correlation between this and the available nutrient salts in the water at the different positions, and to gain some indication of the rate at which the organisms forming the standing crop were themselves growing. The zooplankton populations at the stations were also estimated by vertical hauls with a measuring net of No. 10 bolting silk.

The phytoplankton was estimated from water samples from a series of depths by passing it through filter paper and extracting the plant pigments or chlorophyll. The growth-rate was assessed from the oxygen production, being the difference between increase and decrease in water samples kept

in light and dark bottles at sea temperature — a method used by Gran, Marshall, and Orr and by Jenkin, the limitations of which the author has examined and discussed in previous papers.

The quantity of plant pigments at the four northernmost stations was greatest at the surface and the maximum depth in which they were detected was 100 metres or less. At the southern stations they occurred to a depth of 300 to 400 metres or more, and the maximum values were found at 100 metres; in the surface water the quantity of chlorophyll was half that in the surface water at the northern stations. The total standing crop of phytoplankton in the entire vertical column was considerably greater in the southern stations because it extended to two or three times the depth.

With regard to the growth-rate of the phytoplankton organisms in the surface water, the author summarizes the results of the experiments in light and dark bottles as follows:— "The mean oxygen production in the northern waters was 0·180 mg. per litre per day, about half as much as the value recorded by previous workers for temperate shallow water areas during the spring bloom. In the tropical waters the average was 0·091 mg. Fifty-five per cent. of these variations in oxygen production can be accounted for by differences in the quantity of the standing crop; other factors — temperature, light and nutrients — did not appear to have a significant effect. Although the gross productivity (glucose formation) of the southern surface waters is only half as great as in the north, it is suggested that because of the greater transparency of the water, the total productivity per unit area may be equal to or greater than that of temperate regions."

It has long been known that the phytoplankton population is relatively sparse in tropic waters and that the concentration of available nutrients tends to be kept at a very low level.

Seiwell, from a consideration of the phosphate and oxygen distribution, came to the conclusion that there was a rather considerable replacement of nutrient salts by eddy movement from the richer deep waters and that such tropic waters supported a large annual crop of plant life although the standing crop was always small. His conclusion was based on an assumed maximum value for the eddy coefficient, but a very forcible case for this conclusion was developed. Meanwhile Russell had found that average annual population of zooplankton in the Great Barrier Reef lagoon was similar in magnitude to that in the temperate waters of the English Channel, although the phytoplankton population and the nutrient salts were sparse. Riley has produced evidence, in a previous publication, that the annual production of phytoplankton in shallow Tortugas waters is quite considerable although the standing crop and the concentration of available nutrients is at a very low level. Thus, evidence is accumulating that tropic seas, which appear less fertile, do in fact support the growth during the course of a year of as much, or nearly as much, plant life as temperate regions with their dense spring and autumn blooms.

It is of interest that the author found about as much zooplankton in the water of the southern stations as the annual mean which has been found in the English Channel and other temperate seas. Considerably greater zooplankton populations were found at the more northern stations.

H. W. H.

Knud Jessen and **Ragnar Spärck** (Edited by). "Danish Scientific Investigations in Iran." Part I, pp. viii + 141. Ejnar Munksgaard. Copenhagen, 1939.

This new serial publication is to contain the results of the work carried out by Danish zoologists and botanists mainly in connexion with Dr. H. Blegvad's fishery investigations in the Persian Gulf or Gulf of Iran. The first part, well produced by the publisher, comprises a list of the Lepidoptera by W. Forster, an ecological and systematic description of the little-known marine algal flora by F. Børgesen, and an account of the sea-snakes by Helge Volsøe. The collections of marine algae, specially made by Mag. Køie in the inner part of the gulf, showed the area to be rather poor in species, but provided material for the first comprehensive account of these groups from the region in question. The paper on the sea-snakes deals from a systematic and zoogeographical point of view with the nine species found in the Persian Gulf and the Gulf of Oman, and it also contains a very interesting discussion of the structural and behavioural adaptations to a marine life of these remarkable forms, based on a survey of the rather scanty literature.

E. S. R.

H. W. Harvey. "Nitrogen and phosphorus required for the growth of phytoplankton." Journ. Mar. Biol. Assoc., U. K., Vol. 24, No. 1, pp. 115—123, 2 figs. Cambridge, 1940.

This paper describes observations in which mixed communities of marine diatoms were grown (in the laboratory) in sea water through which washed and filtered air was rapidly bubbled to ensure an adequate CO_2 supply. Nutrient salts likely to be limiting were added — these normally included sources of nitrogen and phosphorus, silica and iron. No special precautions against bacterial contamination were taken as it was assumed that bacteria were normally present on the plankton organisms. Growth was estimated by extraction of pigments from centrifuged algae and comparison with standard colorations.

Adding iron and silica (amounts not stated) and varying the amount of added phosphate or nitrate with the other of this pair in small excess (2 mg./l.), it was found that for equal production of diatoms, between nine and ten times more nitrate-N than phosphate-P was required. Analyses given show that this is about the average ratio of N to P in marine diatoms, the values varying from 6·9 to 13·4.

In further experiments, with nitrogen limiting growth, it was found that ammonia-N was used more rapidly than nitrate-N. Urea and uric acid were used more slowly, and apparently without previous conversion to ammonia. On the other hand, though some amino-acids might be as effective as nitrate in promoting growth, the evidence suggests that they are de-aminated by bacteria, ammonia being formed. Trimethylamine oxide had no effect on phytoplankton growth.

When phosphate was limiting growth, sodium nucleinate was as effective as phosphate in increasing growth. Phosphate was rapidly formed from nucleinate in the dark, but only in water not filtered through a Seitz filter. A caseinate gave slow growth but glycero-phosphate appeared to be without effect.

W. H. P.

W. R. Coe and **W. E. Allen.** "Growth of Sedentary Marine Organisms on Experimental Blocks and Plates for nine successive years at the pier of the Scripps Institution of Oceanography." Bull. Scripps Inst. Oceanogr., Tech. Ser., Vol. 4, No. 4. Berkeley, Calif., 1937.

In this paper are given the results of nine years' experiments and observations on the marine growths obtained on blocks and plates immersed in the sea from a pier at La Jolla, California. Blocks made of wood and cement were first used, along with cement plates in a frame. These were discarded later for frames containing plate glass. The apparatus could be raised from, and lowered into, the sea from the pier platform. Differential environmental effects were noted for different situations, and certain organisms, as barnacles, settled preferentially on cement or on other barnacles or oysters; others, as oysters, preferred the under-surface of the concete plates. More growth was obtained usually on the outer than the inner surface of the glass plates, and more also in the first few weeks on the upper than on the lower halves of the glass plates. More growth was also obtained on scraped plates which remained wet than on scraped, dried, and sterilized plates; the greater growth on wet plates is suggested to be due to the retention of microscopic organisms and particles from previous growths offering a more favourable settling and feeding surface. The greater abundance of oysters on under surfaces is said to be due to the position in which the larva holds the body in swimming, and not because of phototropic stimuli.

The most abundant kinds of organisms obtained were Ectocarpus, diatoms, hydroids, barnacles, oysters, Bryozoa, Serpulids, Herposiphonia, and in some years Erichthonius. In the different years the organisms varied in their times of maximum abundance, believed in some cases to be correlated with environmental differences, particularly temperature, but in the whole period the seasonal abundance of the first seven of these — as determined by volume — gives smooth graphs which indicate reasonable rhythmic periods. In these periods hydroids show two maxima, one in spring and another of much interest in October—December.

The other dominant organisms exhibit only one maximum, a long-drawn-out cold period one for Ectocarpus and especially diatoms, and summer maxima for the rest.

The reviewer is impressed by the striking similarity of the types in this fauna at La Jolla with those found on buoys and piers in the south of England: the associations are clearly comparable and of a fairly definite composition. We now await studies on the biology of the constituent members of these ecological groups to explain their occurrence and relationships.

J. H. Orton.

R. V. Truitt. "Our Water Resources and their Conservation." Issued by the Maryland Conservation Department, U.S.A., 1939. Pp. 103.

Dr. Truitt, who is Director of the active Marine Biological Laboratory situated on Solomon's Island, near the entrance to Chesapeake Bay, gives here a very interesting account of the fishery resources of this remarkable area of water, which stretches for many miles along the coast of Maryland, cut off from the ocean for most of its length by a long peninsula. It receives a great deal of fresh water from the large rivers that flow into it, and has some of the characteristics of an estuary. It is one of the richest fishery areas known, its 20,700 square miles producing in 1920 an average of 11 tons of

fish per square mile. It is famous especially for its oyster, *O. virginica,* the fishery employing some 10,000 men; for its crab, *Callinectes sapidus,* which gourmets eat in its soft-shelled state; for its shad, *Alosa sapidissima;* for its striped bass, *Roccus lineatus,* and its many sport fishes. Other succulent products are the canvas-back duck and the diamond-back terrapin.

Dr. Truitt gives an excellent popular account of the structure and natural history especially of the crab and the oyster, with adequate illustrations, and a full description of the fisheries and fishery methods. His main object is to interest his fellow citizens in the valuable resources at their doors, to point out the dangers of depletion, and to advocate sane measures of conservation. Practically all the species have suffered heavy depletion, largely due to over-fishing and poor husbanding, and there is urgent need for building up the stocks again. We on this side of the Atlantic who have to face the same problem of over-fishing will wish Dr. Truitt every success in his public-spirited campaign.

E. S. R.

J. R. Bruce, Margery Knight and **Mary W. Parke.** "The Rearing of Oyster Larvae on Algal Diet." Journ. Mar. Biol. Assoc., Vol. 24, No. 1, pp. 337—374, Cambridge, 1940.

This is a report on investigations undertaken by the authors at the Biological Station in Port Erin concerning the rearing of oyster larvae under laboratory conditions. The authors paid particular attention to the problem of food of the free-swimming larvae, and their account is chiefly based on the remarkably good results of the 1938 season. The feeding experiments were set up in a specially built culture house with facilities for temperature control. Glass bell-jars (20 l. capacity) served as experimental vessels, and a variety of sources of water was tried out. Stirring and aeration was provided by glass plunger plates and/or bubbling through of compressed air.

The most important results were obtained with filtered "outside" sea water as medium and pure cultures of autotrophic nannoplankton flagellates — Chrysophyceae and Chlorophyceae, 1·5—7 μ in size — as food. Six such flagellates ("B", "C", "D", "F", "H", "I"), cultured in "Erdschreiber" medium, were employed and, while no settlement occurred in jars to which "D" was added as food, settlement up to 95 % of the larvae was obtained with the other food organisms. The authors can justly claim that "the feasibility of rearing oyster larvae by artificial feeding has now been definitely established", — a fact which was already indicated by Cole (Fishery Invest., Ser. II, Vol. 15, No. 4, 1937) who obtained significant, though less spectacular, growth of oyster larvae by feeding with cultures of "C", "H" and similar flagellates.

Several of the flagellate cultures ("B", "C", "D", "F", "H") were placed at the disposal of the authors by the reviewer. A regrettable confusion, however, was created as regards "D", the description of which (4—7 μ, red) does not conform to the original "D" in the possession of the reviewer (1·5—2 μ, yellow-green). Thus the original culture of "D" either became contaminated and finally suppressed by the red flagellate in Port Erin, or the authors applied the label "D" to a different species isolated by them. It is a serious gap in our knowledge of marine phytoplankton that those minute autotrophic flagellates have not yet been properly studied and identified, but as long as we have no better names it would seem advisable to respect the preliminary

labels given by those who have isolated them in a culture, and thus to avoid that a flagellate with the same "label" has different pigments in different papers.

The six flagellates seem to differ in their usefulness as food. But in view of the inconsistency of the results obtained with one and the same organism in successive experiments, it seems doubtful whether the differences are statistically significant and whether they justify the assessment of the food value of the different flagellates as suggested by the authors.

As regards the culture medium ("Erdschreiber") the authors state that its effect *per se* on the larvae was found to be negligible. However, this conclusion is based on a set of experiments (Table VI) which cannot possibly justify it. These experiments only show (1) that no growth took place in the absence of food even when "Erdschreiber" was added, and (2) that some growth took place when "Erdschreiber" was added and food was provided. In order to test the importance of "Erdschreiber" *per se* the larvae would have to be kept in filtered sea water and flagellates added which were grown in filtered sea water or were cleaned in some way of the "Erdschreiber" in which they were grown.

F. Gross.

Ad. S. Jensen, W. Lundbeck, Th. Mortensen, and **R. Spärck** (Edited by). "The Zoology of the Faroes". Andr. Fred. Høst & Son, Copenhagen. 1st volume issued 1937.

A. Friðriksson, S. L. Tuxen and others (Edited by). "The Zoology of Iceland". Ejnar Munksgaard. Copenhagen and Reykjavik. Issued in separate numbers since 1937.

The rapid changes which have taken place in the study of geography and the growing interest in œcology have recently brought about a revival of interest in faunistic studies. Both the North Sea and the Baltic have been well studied and there are indications that even in the British Isles, where for many years such studies have been under a cloud, the marine fauna is again attracting attention. It is, therefore, most fortunate that the Carlsberg-Fond is now financing two faunistic works of primary importance. These works are issued in parts and those that have come to my hands are of a high standard. The Marine Crustacea in particular are most excellently treated as was to be expected from such a first class worker as K. Stephensen.

In the marine groups the lists of species give one confidence that the fauna has been collected in a satisfactory manner and that, although further collecting will add to the lists, additions are unlikely to be great. The freshwater fauna on the other hand does not, in all cases, appear to have been adequately collected. The Copepoda, for example, are organisms which have a wide distribution — there is usually a rich fauna even in the most inaccessible regions — yet twelve species only are recorded from the Faroe Islands. The Ostracoda seem to have been even more neglected; three only, of these ubiquitous crustacea, is the total recorded. If these figures are approximately correct the degree of isolation enjoyed by the Faroe Islands must be great or the most unusual œcological conditions prevail there. The disproportionately high number of the Cladocera suggests that conditions are not very unusual; it is the collecting which is at fault. The deplorable habit of confining the study of the freshwater fauna to that small moiety which can be taken by

the tow-net is a source of many imperfect lists and no doubt accounts for these as well as for the meagre results of several other expeditions.

It is fortunate that in these works the land fauna is included. Both the Crustacea and Coleoptera are so poorly represented or so badly collected in the fresh waters of the Faroes that little value can be attached to any analysis that might be made of these lists. The marine zoologists must, however, have some zoogeographical basis for his study of the marine fauna, apart from the internal evidences to be obtained from it, or his work will prove both difficult and unsatisfactory. In a continuous medium the distribution of forms with pelagic stages is likely to be wide and limited by œcological conditions rather than by geographical peculiarities, save only the presence of strong and continuous currents. The distribution, however, of forms which do not possess pelagic stages, such as many Pericarida, may be limited by geographical barriers such as deep channels, recently submerged land masses, etc., as much as by the presence or absence of suitable habitats. Their distribution results from the past and present geographical position quite as much as from the œcological conditions of the region under consideration. It is clearly of the first importance to discover what the past geographical position has been. Land bridges serve equally as means of dispersal to marine and terrestrial organisms and also as barriers to the former. The peculiarities of the fauna of the North Sea and the coast of Norway can be largely accounted for on such considerations. Zoologists who deal with terrestrial organisms are accustomed to postulate the presence of land bridges on the flimsiest evidence and unless their evidence is available for critical study their views may be given greater weight than they deserve. W o l f f in his account of the Lepidoptera of the Faroes lists only thirty-two species; of these two appear to have reached the islands by aerial migration at least once during the last fifty years, and four others he believes to have been introduced by man. The frequent appearance of moths and other insects on ships far distant from any land is well known, yet W o l f f postulates a land bridge to account for the presence of the remaining twenty-four species! So far as the evidence which is before me goes, and I have examined the lists of freshwater and terrestrial Crustacea, Coleoptera, Lepidoptera, etc., there appears to be no evidence of any post-glacial land bridge; indeed the character of the fauna and its extreme poverty suggest strongly that no such bridge has existed.

In the marine fauna of the Faroes there are many absences which are difficult to account for on œcological grounds. The absence of some Tanaidacea and a few Isopods may be due to lack of suitable habitats, while others may be due to imperfect collecting, but a glance at the lists will show a number of species, occurring in Norway or Northern Scotland, unlikely to be missing from the Faroe lists on such grounds. These absences are probably to be accounted for on an hypothesis of geographical isolation, just as we can account for the peculiarities of the North Sea fauna and the remarkable distribution of organisms in the English Channel by a study of post-glacial geography.

It is most unfortunate that our knowledge of the British marine fauna is so inadequate. The information available is, actually, not so incomplete as might be supposed, but it is scattered and difficult to search out and there is no comprehensive treatment of the majority of the groups of marine organisms. This no doubt accounts for S t e p h e n s e n's statement that *Idotea viridis* occurs in Ireland only: it is, in fact, abundant on the south and east coasts of England and occurs so far north as the Kingdom of Fife.

Until the distribution of British fauna is better known the true value of the two excellent works under review will not be made manifest. That they will then serve to answer many questions is probable, but all that can now be said is that they are well printed, carefully compiled and edited, mines of valuable information, and that they should be in the library of every institution and every individual interested in the study of the marine fauna of the Northern Hemisphere.

J. O.-C.

Current Bibliography.

Prepared by the Editor.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The present instalment covers only part of the literature published during the war years. As not all publications have yet come to hand, and may be overlooked, the Editor would especially welcome advice of any emendations and additions that may come to the reader's notice.

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Table of Contents.

Page

1. Obituary: Members of the Council deceased since 1939 3
2. **Alf Dannevig.** The Flødevig Sea Fish Hatchery at Arendal, Norway 7
3. **J. N. Carruthers.** Practical Proposals for a Continuous Programme of Thick-Layer Current Measuring in all Weathers, with Remarks on Relevant Wind Observations and other Related Matters 13
4. **Jens Smed.** The Inflow of Atlantic Water into the North Sea through the Orkney-Shetland Channel 27
5. **N. G. Johnson and F. Koczy.** Records of Transparency in Gullmar Fjord 39
6. **R. J. Daniel.** The Growth-Rate of Whitebait Herring of the North Wales Coast 42
7. **Bennet B. Rae.** Review of the Scottish Lemon Sole Fishery at Faroe with Special Reference to the Years 1933 to 1938 61
8. **André Capart.** Le *Lernaeocera branchialis* (L.) Copépode parasite des Gadides 69
9. Note. Establishment of a Division of Oceanography in the United States Navy Hydrographic Office 77
10. Reviews 79
11. Current Bibliography prepared by the Editor 90

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